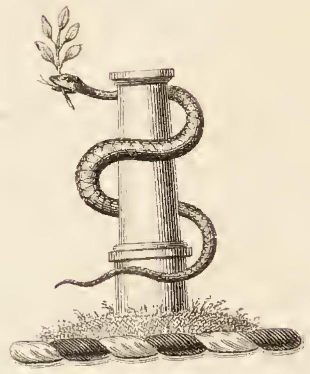

Henry Coles.

Henry Cole

Aug 24th 1907.

CALORIC

IN TWO VOLUMES

VOL II

"To every form of being is assigned
An active principle: howe'er removed
From sense and observation, it subsists
In all things, in all natures, in the stars
Of azure heaven, the unenduring clouds,
In flower and tree, in every pebbly stone
That paves the brooks, the stationary rocks,
The moving waters, and the invisible air.
*   *   *   *   from link to link
It circulates, the soul of all the worlds."

WORDSWORTH.

CALORIC

ITS MECHANICAL CHEMICAL AND VITAL AGENCIES IN THE PHENOMENA OF NATURE

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VOL II

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BOOK IV.

CHAPTER I.

Life.

" First then, if any one think that the secrets of nature remain shut up, as it were with the seal of God, and by some divine mandate interdicted to human wisdom, we shall address ourselves to remove this weak and jealous notion; and, relying on simple truth, shall bring the inquiry to this issue, not only to silence the howl of superstition, but to draw religion herself to our side."

BACON.

WHETHER in a theoretical or practical point of view, the animating principle is the most important problem that ever engaged the attention of mankind; for it connects all that is profound and fascinating in physics, with the science of preserving health and prolonging life. Never can the healing art take its appropriate rank among the exact sciences until the cause of vital force and animal motion is distinguished from the operations which it produces; but must remain, as in all the ages that are past, a mere collection of empirical rules. If it be true that every deviation from health is immediately connected with some derangement of the vital principle, there cannot be a doubt, that a clear comprehension

of what it is, and of the laws by which it operates, would do more to meliorate the condition of mankind, than all the systems that have been invented from the age of Hippocrates to the present time; because it would lead, not only to a certain method of curing diseases, but, what would be of vastly greater consequence, the theory of life would become intelligible to all; and its chief glory would be the prevention rather than the cure of maladies.

The whole object of medical science is to regulate the forces of life—to increase them when and where they are deficient—to restrain them when excessive—and to restore their natural balance when deranged. But how can we know the best means of maintaining the functions of life in a healthy state, while ignorant of the physical cause on which they all depend? How is it possible to counteract with certainty, those involuntary movements that constitute tetanus, hydrophobia, and other forms of convulsive disease, without knowing the cause of muscular contraction in a state of health? How can we adopt the best treatment of fever, inflammation, and the various species of malarious affections, without comprehending the true theory of animal heat, and the specific office which it performs in the economy of life? Why are so many diseases pronounced incurable, though attended with no organic lesion, and ranked among the *opprobria*

medicorum, but that men are ignorant of what causes the heart to beat, the stomach to digest, the brain to think, the nerves to feel, and our active limbs to move?

The true panacea, or elixir of life, must not be sought in specifics and nostrums, but in a clear and definite knowledge of the mode in which the organizing principle operates in the different functions of life. Were it not that all the phenomena of nature are linked together as parts of one great whole, it would be of far higher importance to know the cause of vital, than that of planetary motion. Nor was it ever intended by Infinite Wisdom and Goodness, that knowledge so essential to the happiness of our race should remain a sealed book. Life is the problem of problems, the solution of which would clear up a thousand other mysteries, and banish innumerable errors from the pages of science. And it may be asserted with confidence, that whoever is without faith in the power of well-directed efforts to resolve it, will never accomplish much towards enlarging the empire of man over the numerous evils by which he is surrounded. A complete knowledge of this subject would do more to elevate the condition of mankind, than the power of transmuting the baser metals into gold, or even charcoal into the precious diamond; for all the riches of the earth are not to be compared with health.

But, unfortunately for the best interests of the world, an impression has long prevailed, that the animating principle is something beyond the powers of the human mind to comprehend. That such dogmas should have been inculcated by the founders of narrow creeds, and individuals interested in keeping the people in ignorance, is not to be wondered at; for in all ages of the world, the empire of imposture has been founded on pretended mysteries, and upheld by ignorance. It is, however, melancholy to reflect, that philosophers have given countenance to this prejudice. Enslaved by ancient errors, even the wise Socrates is said to have thought it dangerous, unprofitable, and not acceptable to the gods, for men to pry into the hidden mechanism of nature. And in an article on Life, contained in his Philosophical Dictionary, Voltaire, a professed champion of free inquiry, asserts, that "the cause of animal motion, like that which determines all things to a common centre, and the needle to the pole, is the secret of the Deity." The general adoption of this opinion by the instructors of mankind, has done immense injury to the cause of science, by discouraging the efforts of genius to press forward into the undiscovered regions of truth; while it has fostered ignorance, indolence, and every description of quackery. If there be any primary and efficient cause of vital force, it must be either a portion of the air we breathe, or of the

materials by which we are nourished; and if so, there is no good reason why it should be more mysterious than any of the other phenomena of nature.

It was remarked by Cicero, that "to be ignorant of what has been done before our time, is ever to remain in a state of childhood;" and Lord Bacon observes, that "whoever undertakes to investigate the first principles of science, should know the opinions of the ancients concerning the foundations of nature." Coinciding with these views, and having often felt the want of such information, I shall give a brief outline of the leading doctrines which have come down to us from a remote antiquity, in regard to the primary cause of motion and life throughout nature.

From the earliest dawn of civilization, men sought to resolve this great problem: and there is nothing more remarkable in the history of mankind, than the universal consent with which they regarded elementary fire as the organizing principle; a doctrine which, although but vaguely understood by the ancients, was the basis of all their physical theories; and which, when clearly unfolded, is destined to survive all the more elaborate systems of later ages, because it was the result of observation, experience, and the dictates of common sense. Yet as it was mingled with many superstitious and fabulous traditions of the ancient paganism, it has been almost wholly disregarded by the moderns: the con-

sequence of which has been that not one of their philosophical systems has been able to gain a permanent footing in the world, nor to resist the force of that universal common sense by which all partial and contradictory theories are, sooner or later, swept away.

It was from beholding everywhere the transforming and life-giving power of the sun, as displayed in the generation and growth of organized bodies, that all the early nations of the earth were led to regard that glorious luminary as the supreme Lord of creation, and as the special object of religious adoration. In accordance with the views of Macrobius, it has been fully established by the learned researches of Bryant, Dupuis, Sir William Jones, and many other distinguished oriental scholars, that all the deities of the ancient world are resolvable into the powers of nature, and that they were mythological personations of the sun or solar fire, by which everything is produced.*

* The primitive solar worship is strikingly illustrated in the following passage, (translated from one of the Vedas, or ancient Hindoo scriptures, by Sir W. Jones,) which also contains the germ of what is called the oriental theory of emanations, referred to in a note to page 105, b. i. : " Let us adore the supremacy of that divine sun, the god-head who illuminates all, from whom all proceed, to whom all must return, whom we invoke to direct our understandings aright, in our progress towards his holy seat." (Asiatic Researches, vol. i.)

It may also be worthy of notice, that in the ancient Sanscrit, the seven days of the week are called after the heavenly bodies; Sunday after the sun, to which that day was consecrated; Monday after the moon, Tuesday after Mars, Wednesday after Mercury,

It was because the old Sabeans regarded fire as the universal spirit or soul of nature, that they worshipped the sun, moon, and planets, with all the host of heaven, which they represented as the body of God. It was the sun that was adored as the fountain of light, life, wisdom and goodness, in ancient India, under the titles of *Boodh-ha* and *Chreeshna;* which, in the old Celtic language of Ireland, also signify the sun, according to Higgins. (Anacalypsis, vol. i. p. 159.) The Baal and Belus of the early Chaldeans were names of the solar orb, which they represented as the seven-rayed god that fills the planets with life, power, and harmonic motion. Nor is it less certain, that under the various titles of Saturn, Jove, Osiris, Vulcan, Hercules, Molech, Elion, Adonis, Jupiter, Apollo, Pan, Dionusus, Esculapius, and a multitude of other appellations, the worship of fire was practised for thousands of years in Egypt, Phœnicia, Arabia, Persia, Greece, Italy, and among all the ancient tribes of Europe.* Nor is it sur-

Thursday after Jupiter, Friday after Venus, and Saturday after Saturn, as in several of the more modern languages, including French and Italian.

* Under the mythological titles of *Boodh* and *Fo*, the sun has been worshipped from the earliest ages to the present time, in the vast empire of China, where elementary fire is still regarded as the formative principle, which was called *Tien* by the great Confucius and his disciples. Nor is it unworthy of notice, that the ancient Persians represented light as the source of all good, and darkness as the evil principle, which according to Bishop Theodorus, they termed Satana, or Arimanius. (Enfield's Hist.

prizing, that in the absence of revelation, all the religious and philosophical systems of mankind should have been founded on the sensible operations of the material universe.

The truth is, that all the names of the Supreme Being in the ancient Hebrew, as in every other written language, seem to have been originally derived from the operations of the sun, light, or fire, as we learn from the researches of Bryant, Parkhurst, and other learned etymologists.

Innumerable passages might be quoted from both the Old and New Testaments, in which the Creator of all things is represented by the brightness of the sun, and under the similitude of light or fire, as in the burning bush, the lightnings of Sinai, the pillar of fire, the vision of Ezekiel, who beheld brightness and flashes of lightning; that of Daniel, to whom the throne of God appeared like a fiery flame; the representation of angels as fiery spirits or seraphs; and the cloven tongues of fire that appeared on the day of Pentecost. There are also many

of Philosophy, vol. i. p. 64.) We also learn from Macrobius, that in Egypt, as in several other oriental countries, the sun was worshipped under the symbol of a bull, which, like the ram, the serpent, and many other animals dedicated to the sun, were regarded as sacred by the vulgar. And so deeply rooted was this superstition among the Israelites, that they made them a golden calf in the wilderness. We further read in the books of the Kings, Chronicles, and Prophets, that under the titles of *Baal*, *Moloch*, and *Chemosh*, the Chaldean and Phœnician worship of the sun was almost constantly practised by the Jews in groves and high places.

other passages in the sacred writings in which the Deity is more especially described as residing in, and operating through the agency of light or fire: "who dwelleth in light inaccessible and full of glory—who is clothed with light as with a garment—who maketh his ministers a flaming fire," &c.

Whatever may be the true interpretation of such language, it clearly shews how exalted were the views of the inspired writers in regard to the agency of light in the work of the universe. The plain matter of fact is, that there is nothing in nature so divinely pure, spiritual, and beautiful as light. By means of this ætherial medium, we hold communion with the starry worlds, and journey as on the wings of imagination, through the celestial plains. The health and spirits of all animated beings are awakened to renewed energy by the solar rays; but languish in their absence, or when intercepted by mists and clouds. When surrounded with cold and darkness, the brightness of fancy, like the external colours of creation, is quenched, and all the energies of life are brought low.

The unsophisticated language of mankind, in every age and country, has been obviously founded on the intuitive belief, that fire is in some way immediately connected with all the operations of life, sensation, and thought. The following expressions are not merely metaphorical, but vivid and faithful representations of nature,

derived from experience and observation:—*The lamp of life, the glow of health, the warm vigour of youth, the lustre of a beaming eye, the brightness of fancy, the light of reason, the fire of genius, the heat of passion, the chillness of age, and the coldness of death,*—with a thousand others that might be adduced, which are not less philosophically correct than poetically beautiful.

In the mythology of Greece, the germs of which were derived chiefly from the traditions of a remote antiquity, the solar orb was represented, under the name of Apollo, as the god of health, poetry, and song; or as the *grand dispenser of life, and the universal Poet of nature.* The harp of Memnon, that responded in sweet and melodious tones to the rising sun, was probably intended to represent his benign agency in filling the world with music and gladness. When he sheds his beams upon the earth the still air begins to move, and resound through the groves with gentle murmurs; while the waves of the sea re-echo with a bolder song. When the sun returns from beyond the equinoctial line, to recall the sleeping world to a new existence, the icy bands of winter give way, when the floods leap forth, and join the universal chorus of the living world. The buds of leaves and flowers expand; the fields are clothed with a verdant carpet; the trees with luxuriant foliage—and we can almost hear the fluids gushing through their veins.

The earliest teacher of art among the Greeks, was Prometheus, an Egyptian, who has been represented in fable as stealing fire from heaven. But it is probable that he merely taught them the use of fire, in the manufacture of metals, and the other arts of life. Cecrops, who introduced the science of agriculture into Greece, was also a native of Egypt ; and Cadmus, who taught the use of letters, was from Sidon. But the most re nowned of all the ancient pioneers of civilization among the Greeks, was Orpheus of Thrace, who, after visiting the East, is said to have instructed them in music, poetry, religion, and philosophy. The sum of his doctrine concerning the origin of things, as collected from the fragments of hymns preserved in the writings of Eusebius, Clemens Alexandrinus, Proclus, Cedranus, and Apuleius, and collected by M. Eschenbach, is, that the primitive seeds from which every thing was produced, existed from all eternity in a fluid and chaotic state ; but that at a certain finite period, the formless mass was reduced to order by the agency of an intelligent, eternal, and self-active Æther.* (Enfield, vol. i. pp. 126, and 130.)

* The views of Orpheus concerning the nature of this Æther, and its omnipresent agency in the phenomena of life, may be further seen in the fragment of a hymn De Mundo, translated by M. Good :—

> " Jove is the æther, Jove the boundless fire,
> That fills the world with feeling and desire :"

as also in the following beautiful invocation to light :—

In the Theogony of Hesiod, Chaos and Night were represented under the emblem of an egg, over which the Æther brooded, and disclosed the innumerable forms of things. And it is probable that the fable of Cupid and Psyche was an allegorical impersonation of passive matter, and of the principle by which it is actuated; or that Cupid was intended to represent the universal attraction that causes the loves of the elements, and binds the universe together.

The generation of the world from a fluid and chaotic state, was a leading doctrine in all the ancient oriental cosmogonies, from the time of Moses, Orpheus, and Hesiod, down to the period of Ovid; and may be traced in the writings of Aristotle, Epicurus, Zeno, and the Stoics generally. For example, we are informed in the first chapter of Genesis, that "in the beginning, the earth was without form, and void, and darkness was on the face of the deep." And it is related by Berosus, that the ancient Chaldeans maintained, that in the beginning, all things consisted of a dark fluid mixture, that was separated and reduced to order by the divine power of Belus; and that the

"O thou who fillest the palaces of Jove,
Who flowest round sun, and moon, and stars above;
Pervading, bright, life-giving element;
Supernal ÆTHER, fair and excellent,
Fountain of hope and joy, of light and day,
We own at length thy tranquil sway."

human soul is an emanation from the divine nature. (Enfield, vol. i. p. 54.)

The Egyptian Magi also maintained, that before the regular forms of Nature arose, an eternal chaos existed ; but that the passive and formless mass was reduced to order by the agency of a self-active, intellectual, and eternal Æther, which gradually developed all that we behold of the external universe. (Idem, pp. 89, and 132.) The sum of the Phœnician Cosmogony, as related by Cumberland, on the authority of Sanchoniathon, is, that the elements of all things originally existed in a fluid and chaotic state, until called forth by the energy of a self-active principle, in obedience to the laws of an immutable necessity. It is therefore evident that the generation of all things from Chaos was a fundamental tenet in most of the ancient Theogonies, as described by Ovid:—

> " Ante mare, et terras, et quod tegit omnia cœlum,
> Unus erat toto naturæ vultus in orbe
> Quem dixere Chaos, rudis indigestaque moles,
> Nec quicquam nisi pondus iners congestaque eodem
> Non bene juncturam, discordia semina rerum."
>
> (Met. Lib. 1. v. 5.)

Whatever may have been the origin of this widely diffused tradition, it contains at least a nucleus of truth ; for it is certain, that all the forms of nature with which we are acquainted, have actually emerged from a fluid state. The primitive mountains of the globe have been formed from a state of fusion by fire—and the sediment-

ary rocks from a state of solution in the water of lakes and seas ; or from the ruins of mountains and elevated plains, that have been carried down by rains, rivers, and springs, in a state of chaotic mixture. Plants are formed from sap, and animals from blood, in which all their organs are confounded, until developed by the powers of life. And if it be true that the planets have been formed from the aggregation of phosphorescent nebulous matter, in which all the elements, active and passive, are mixed up, and confounded, it presents the most important physical conditions of the ancient chaos. The successive destruction of the world by alternate submersions and conflagrations, and its renovation from a state of dissolution, was another doctrine of antiquity, that may have originated from a confused notion of the perpetually destroying and regenerating influences that make up the history of universal chemistry, geology, life, and death.

The first philosopher who introduced an exact method of studying nature among the Greeks, was Thales of Miletus, who was descended from Phœnician parents, and flourished about six hundred years before the commencement of our era. This illustrious founder of what has been called the Ionian school, after travelling through the East, for the purpose of acquiring knowledge among the renowned magi of Egypt, returned to his native country, where he laid the foundation

of mathematical and physical science on the basis of established principles. With the sages of the oriental nations, he maintained the existence of an omnipresent fiery æther, as the primary efficient cause of motion throughout the universe; and which he termed *αυτοκινητον*, for the purpose of representing its self-moving power. According to Cicero, he also regarded it as the soul or mind of universal nature, because he conceived that a self-moving principle, wherever it exists, must have intelligence. (De Natura Deorum, lib. i.) Aristotle termed it *κινητικον*, as indicating its power of giving motion to other bodies. (De Anima, lib. i. c. 2.) By the energy of this principle, Thales maintained that the passive elements of matter were reduced to order from a fluid state, and that it is the proximate cause of life in plants and animals.

In conformity with the above doctrine, Parmenides and Archelaus maintained that heat was the cause of motion, and cold of rest; or that heat and cold were the first principles of action in nature. Heraclitus also regarded fire as the cause of energy throughout the universe; and as it seemed to produce all effects in a regular series, in obedience to perfectly wise laws, he conceived that it must be omniscient and divine.

It has been often asserted by both ancient and modern writers, that Democritus denied the existence of any independent principle as the

primary and efficient cause of motion and life in the universe, distinct from the primitive, indivisible, and immutable atoms of matter; which he supposed were all of the same essential nature, but different in form and magnitude. It has been said that he referred all the generations and dissolutions of bodies to certain innate forces of attraction and repulsion, residing in these ultimate atoms; and that the various properties of bodies are owing to the different mode of their arrangement, as determined by the inherent powers of atoms. But Lucretius says that Democritus regarded heat as composed of exceedingly small atoms of a round form, more active and penetrating than those of other matter; and, the soul or animating principle in man, as a portion of the same fiery nature that actuates the universe. With very slight variations, the Epicurean theory of physics was a copy of the above doctrines.

Another distinguished teacher of natural philosophy among the Greeks, was Pythagoras, the son of a Tyrian merchant, born in the island of Samos 586 A. C. After visiting the different countries of the East, and residing twenty years in Egypt in quest of wisdom, he established a school of science in his native place, and afterwards at Crotona in Western Greece, from which he was driven by persecution to Metapontum, where he is said to have perished of hunger in

the temple of the Muses; a martyr to the ignorant jealousy of his enemies.

The sum of his doctrine concerning the *primum mobile* of nature was, that it is an all-pervading fiery æther of boundless energy, possessing within itself the united power of motion and intelligence, αὐτοματισμὸς τῶν παντῶν, *the self-moving principle of all things;* and that the human soul is a portion of the same essence. This first principle of action in nature he represented as *unity;* the passive elements of matter as *duad;* and the universe perfectly formed as a physical *triad*, all the operations of which are governed by exact numerical laws. He also maintained that the earth and heavenly bodies revolve around a fixed fiery globe; and that the spheres of the different planets, by striking against the æther through which they pass, must produce sounds that vary according to their magnitude, velocity, and distance from the centre of motion—those which are farthest off, producing the deepest, and the nearest the highest tones:*

> "For ever singing as they shine,
> The hand that made them is divine."—ADDISON.

Whether anything more was intended than to represent the harmonious relations between the times, distances, magnitude, and velocity of the

* Aristotle, Meteor. lib. i. c. 6. Plutarch, de Placita Philosophorum, lib. iii. c. 2.

heavenly bodies, the music of the spheres* is the finest conception of all antiquity, and is said to have led Kepler to the most important discovery ever made in astronomy; viz. that the times in which the planets perform their revolutions are as the cubes of their distance from the sun. Nor is it unworthy of notice, that as the velocity of the planets is in proportion to the heating power of the sun, so the velocity with which

* The earliest mention of this celestial harmony is found in the Book of Job, where it is said that when the work of creation was finished, "the morning stars sang together;" and it has been consecrated by the noblest poets of modern times.

"Look how the floor of heaven
Is thick inlaid with patines of bright gold:
There's not the smallest orb 'mong all which thou behold'st,
But in its motion like an angel sings,
Still quiring to the young-eyed cherubim," &c.

SHAKESPEARE.

It is also grandly expressed in the following lines from an Ode of Milton on the Nativity:

"Ring out, ye crystal spheres,
And let your silver chime
Move in melodious time,
And let the base of heaven's deep organ blow;
And with your ninefold harmony,
Make up full concert to the angelic symphony."

A still more philosophical account of this great music is contained in the opening chorus of Faustus, by Goëthe; who refers it to the fountain of all harmony:

"The sun his ancient hymn of wonder
Is pouring out to kindred spheres,
And still pursues with march of thunder
His preappointed course of years," &c

sounds are propagated through gases and other vibrating media, is in proportion to the amount of caloric around their particles, *ceteris paribus.*

About fifty years after Pythagoras, arose Hippocrates, who flourished in the age of Anaxagoras, Socrates, Heraclitus, and Democritus, when Greece was the centre of light and civilization to the whole world. To this illustrious man is due the glory of having reduced the healing art to a regular and systematic form. He maintained that, although it is not the province of the physician to speak of divine things, unless so far as they may serve to improve our knowledge of the causes and nature of the diseases incident to the human body, it is yet necessary for him to lay down some general principle from which he may reason. He then declares his opinion, that elementary fire is the cause of perpetual motion throughout the universe, and when united with organized bodies, constitutes the animating principle; that it resides in all matter, producing an endless variety of effects, according to fixed and definite laws; and that, as it operates with consummate skill in the generation of animal motion, sensation, and intelligence, it must be something immortal, that sees, hears, and knows all things. This mighty agent, which he terms φυσις or *nature*, was supposed to produce all the phenomena of living bodies, by attracting what is necessary for their developement, and expelling

whatever is superfluous or injurious; and he maintained that the science of medicine should be founded on a comprehensive knowledge of the mode in which it governs all the operations of nature; *κατα φυσιν θεωρεων*. (De Principiis, et de Alimento.)

He maintained that the solid parts of animals, and their various secretions, were formed from the blood, which was composed of four primary humours, corresponding with the four proximate constituents of modern physiologists, viz. red particles, fibrine, albumen, and serum. But he supposed that the liver was the great organ of sanguification, and termed the cardinal humours, red blood, black bile, yellow bile, and phlegm. On the qualities and relative proportions of these four humours, all the diversities of the constitution were supposed to depend. An abundance of red blood was marked by a warm and sanguine temperament; whereas, an excess of yellow bile produced the choleric temperament, both of which were warm, and characterized by a high degree of vital energy. On the other hand, the melancholy temperament was supposed to arise from an excess of black bile, and the phlegmatic from a predominance of phlegm, both of which were cold, and marked by a general debility of the system. But it is evident, that what Hippocrates called phlegm, was only another name for the serous portion of the blood; and that he confounded the dark venous

blood which abounds in feeble, melancholy constitutions, with black bile. It is equally certain, that what he called red blood, was what we term arterial blood, the abundance of which is marked by a vigorous, sanguine temperament. And there is good reason to believe, that the yellow bile of Hippocrates was only another name for the coagulating lymph, or fibrine; as he supposed that it imparted a yellow colour to the watery portion of the blood; for the bile secreted by the liver never produces this effect, unless when the system is in a diseased state.*

The pathological views of Hippocrates were founded on the above doctrines. He taught, that whatever alters the natural condition of the

* Several passages were published in the Lancet of September, 1835, by Mr. Girtin, from the writings of Hippocrates, which, taken separately, would seem to shew that he was acquainted with the circulation. For example, in his treatise *de Insomniis*, as quoted by Mr. Girtin from the Vander Linden edition of his works, he observes, that "rivers return to their sources in an unaccountable and extraordinary manner, like the circulation of the blood." (Tom. i. p. 460.) In another treatise, he says, "I protest I know not where it begins, nor where it ends, for in a circle there is neither beginning nor ending." (Idem, de Alimento, tom. i. p. 596.) "The heart and veins are always in motion." (Idem, de Principiis, tom. i. p. 116.) But there are many passages in the writings of Hippocrates, Plato, and Aristotle, which prove that they regarded the arteries as destined to convey spirits and heat to all parts of the body, and the veins as blood vessels. When describing the use of different parts of the body, Galen says, that air was supposed to be taken into the lungs, where the most pure and subtile portion was separated from

fluids, whether impure air, bad diet, want of rest, fatigue, retention of the excretions, or the depressing passions of the mind, deranges the healthy condition of the whole system; that inflammation or fever is an effort of nature, or the φυσις to expel morbific matter from the humours; and that the highest wisdom of the physician is to follow the proceedings of nature in practice: above all, to preserve and restore the healthy condition of the blood by nutritious food, pure air, exercise, &c.; to moderate its motions when excessive, and increase them when languid; to open the bowels, skin, and other

it, conveyed from the trachea to the heart, and thence to all parts of the body by the arteries, which they called *pneumatic vessels;* and that the fuliginous portion of the air was thrown off from the lungs by expiration. He further states, that all the Greeks, from Hippocrates down to his own time, believed that after food was dissolved in the stomach, it was conveyed to the intestines, and thence to the liver, where it was converted into blood, prepared for nutrition, and then conveyed to the *vena cava*, to be distributed to all parts of the system; he further taught that the office of respiration was to *cool* the blood. (De Usu Partium, lib. iv.) It was not until the time of Herophilus and Erasistratus, that the brain and nervous system were fully recognized as the organ of sensation, perception, and voluntary motion. Nor was it until the middle of the sixteenth century, that Servetus distinguished the pulmonary circulation from that of the general system; or, that the lungs were discovered to be the organ of sanguification. It is therefore clear, that the knowledge of the Greeks in regard to the specific office of the lungs, heart, liver, blood vessels, and nerves, was not only vague and imperfect, but fundamentally erroneous.

emunctories when obstructed, and dissipate or resolve tumours by fomentations or cataplasms.

If we pass in review the leading doctrines of the different philosophical sects that arose from the Ionian and Italian schools, we shall find that, while on some points they differed from Thales and Pythagoras, they nearly all maintained that heat is a self-active principle, and the noblest of the elements. Plato, who was born thirty years after Hippocrates, regarded the soul of the world as an all-pervading fire; and he argues in the Timæus, that it is endowed with intelligence, or it could not produce animal motion, sensation, and cogitation, in organized bodies.

But he maintains elsewhere, that the first Mover is an incorporeal, immutable, and eternal intelligence, not appreciable by the senses, the Being of beings, and the Fountain of all law—that the visible forms of nature have been organized by an active principle, possessing the power of moving itself, and of generating organized bodies, after the model of certain ideal archetypes that reside in, or emanate from, the UNCREATED, SUPERESSENTIAL, AND ALL BEAUTEOUS MIND;—by which it is probable, he meant to represent the eternal conceptions of the Infinite Mind in framing the laws of the universe. At one time he refers the origin of evil to the creation of the world by inferior divinities; at another, to an inherent stubbornness, or imperfection of

matter, that could not be entirely overcome by the Supreme Architect.*

In the Treatise of Aristotle concerning the soul, or animating principle, he maintains that a self-active spirit, which he terms Πνευμα or Ψυχη, is the cause of all effects in the living body. To this spirit he ascribed three different faculties; the first of which was manifested in the thorax, and termed vital; the second, or nutritive, in the abdomen; while the third, or reasoning faculty, was supposed to reside in the head. He adds, that whether the vital principle be identical with elementary fire, or something analogous, constituting a *fifth* element, it is a portion of the same principle that maintains the

* There is reason to believe, that a more profound knowledge of nature than the human mind has ever yet attained, will shew that all the works of God are absolutely perfect in their kind; and that

"All partial evil is universal good,
All discord harmony not understood."

In the great circle of unceasing change that makes up the order of things, the earthquake and volcano produce apparent disorder, and sometimes destroy life; but without them the earth would not be fit for the habitation of man. The hurricane and tempest are as necessary to the salubrity of the air, as sunshine and rain to the growth of vegetation. And it is probable, that to a superior intelligence, death would not be regarded as an evil, any more than the ripening and decaying of fruits, or the successions of winter and summer, light and darkness. In short, every thing in the fundamental constitution of nature, and mechanism of the living frame "*is very good;*" *and tends to produce the greatest*

universe in a state of perpetual motion. (De Anima, lib. i. c. 2.)

But in his Metaphysics, he maintains that the First Mover is incorporeal, immutable, immovable, and independent of the material universe. In what way this immaterial First Mover, itself incapable of motion, communicates motion to other bodies, he never clearly explained; but supposed that it acted on the first celestial sphere, in a mode similar to that in which the mind acts on the body. (Lib. xi. c. 6, 7, 8, as cited by Enfield.)

As for the rest, he maintained with Plato, that the earth is the centre of motion to the planetary spheres, the velocities of which are inversely as

amount of happiness to the greatest number of animated beings. Even the passions of the human mind are as necessary to happiness as reason itself; nor is it possible that pleasure could exist without sensibility, or the susceptibility of pain. Let us then confess, that by far the most fruitful source of physical and moral evil is our ignorance of the innumerable springs of happiness that a more perfect knowledge of nature would unfold. The truth is, that the choicest blessings of life become evils when misapplied. The cherishing power of heat, without which nothing could exist, becomes a consuming fire in excess; and so of our food and drink, exercise, repose, and every thing else. The beautiful light of the sun, the physical source of all good, excites inflammation of the eyes, if ignorantly gazed at too long. Nor is it unworthy of notice that misfortune and sorrow have been far more frequently instruments of good than prosperity, by leading thoughtful minds to investigate the causes of human suffering, and the best modes of preventing it.

their distance from the first sphere. (De Cœlo, lib. ii. c. 13, 14.)

It was justly observed by Bacon, that Plato corrupted natural philosophy by mixing it up with theology, as did Aristotle by metaphysical refinements and a sophistical logic. That they were both exceedingly ill informed concerning the nature of heat, will appear from the following examples. Plato says, "It is composed of very fine particles that separate and dissolve bodies, but cold of grosser particles that press upon, and shut up their pores." (Op. vol. iii. p. 100.) From which it is clear, that he confounded a mere privation, or diminution of heat, as darkness is of light, with a material agent; and that he knew not how the same agent produces the opposite effects of attraction and repulsion. Aristotle regarded heat and cold as the cause of density and lightness; but maintains that fire is composed of heat and dryness; air of heat and moisture; water of cold and moisture; earth of cold and dryness; thus confounding mere qualities and modes of being with material agents. Epicurus also maintained that cold is composed of irregular particles that hold bodies together; and that the vital principle is composed of heat, united with different gases,—*calor vitalis ventusque.* (Lucretius, de Natura Rerum, book iii.)

Cicero relates that Zeno, Cleanthes, and the Stoics generally, maintained the existence of an

all-pervading fire as the animating principle, or soul of nature; but that it was governed by the eternal laws of an immutable necessity, which they termed Fate, or Jupiter; and that the mind of man is a spark of the same ætherial principle—that as the loss of *heat* is always attended with the extinction of life, sensation, and thought, it must be a spirit or mind. Cicero adds, "Quoniam ex mundi ardore motus omnis oritur, autem ardor non alieno impulsu sed sua sponte, animus sit necesse est." (De Natura Deorum, lib. ii. c. 12.)

And when summing up the opinions of the most distinguished philosophers of Greece, he observes, that "whatever the nature of the Divinity may be, whether air, fire, or the fifth element of Aristotle, the human soul is a portion of the same divine nature,—that every one is conscious of having within him a something capable of self-motion—and that a principle possessing such a power must be the fountain of motion to every thing else, therefore immortal, according to the reasoning of Socrates and Plato. Hence the swiftness of thought, the powers of memory, the pleasures of heroic virtue; the joy with which we contemplate the boundless extent of the starry heavens, the earth, and sea; and the delight with which the soul traces its connexion with the Eternal Reason from which all causes proceed." (Tus. Disp. lib. i. c. 23.)

Similar views were entertained by Seneca, and the most celebrated of the Roman poets, who speak of the *anima mundi* as an all-pervading fiery æther, which they regarded as the cause of motion throughout nature, and of life in men, beasts, and birds, as in the following lines from the 6th Æneid of Virgil:

> "Principio cœlum, ac terras, camposque liquentes
> Lucentemque globum lunæ, Titaniaque astra,
> *Spiritus intus alit*, totamque infusa per artus.
> *Mens agitat molem*, et magno se corpore miscet," &c.*

The fire that was kept perpetually burning in the temple of Vesta, termed *calor vitalis*, and *ardor cœlestis*, was also a type of that eternal globe of fire the sun, from which it was kindled.

From the foregoing brief summary, the following conclusions may be deduced:

1. That amidst the innumerable conflicting opinions that have prevailed among the most enlightened nations of antiquity, they nearly all united in the belief that fire is the active principle in nature, and the physical cause of life.

2. That the whole universe is composed of two descriptions of matter, the one active, the

* "Know first, a spirit with an active flame
Pervades and animates this mighty frame;
Runs through the watery worlds, the fields of air,
The ponderous earth, the depths of heaven, and there
Glows in the sun, and moon, and every star:
Thus mingling with the mass, the general soul
Lives in the parts, and animates the whole." WARTON.

other passive; and that every thing has been formed from a fluid or chaotic state.

3. That, with very few individual exceptions, they have all maintained the existence of an Intelligent First Cause; whether united with, and constituting the informing mind of the stupendous whole, as taught by the Chaldeans, Egyptians, Phœnicians, Hindoos, Orpheus, Thales, Pythagoras, Hippocrates, and the Stoics; or existing apart from nature, as an incorporeal Intelligence, who governs the universe by delegated laws.

4. That Bishop Berkeley was right in vindicating the ancients from the charge of Atheism, (however erroneous their views concerning the Divine Nature may have been,) which is wholly incompatible with the almost universal belief in a presiding Intelligence.

It was observed by Cicero, that "the higher we ascend towards the origin of antiquity, or the divine descent of knowledge, the more clear are the traces of truth." And notwithstanding many striking exceptions might be adduced in opposition to this remark, it is extremely probable that in the primitive ages of the world, before it was filled with books, and the minds of men withdrawn from the study of things to that of words, they were more open to the genial impulses of nature, and communed with her more familiarly face to face.

In support of Cicero's opinion, it may be worthy of notice, that in the books ascribed to Moses, though not intended to teach the principles of natural science, two fundamental doctrines of physiology are incidentally pointed out. I allude to *the life-sustaining office of the lungs, and the vitality of the blood.* For when it is said, as in the first chapter of Genesis, that "God breathed into the nostrils of man the breath of life, and he became a living soul," we can understand only, that he was created with breathing organs, for the purpose of obtaining life from the atmosphere; which in the book of Job, is termed "the breath of the Almighty." And it is said in the Levitical code, that "the life of all flesh is the blood thereof." The truth of these doctrines is corroborated by the universal language of all enlightened nations, with whom, *to live,* and *breathe,* are synonymous phrases; and who have always represented the destruction of life by the shedding of blood.*

Again, the true doctrine of the solar system, which seems to have been partially anticipated by Pythagoras, was rejected by all his successors, down to the time of Copernicus; while the atomic theory of Moschus, Thales, Pythagoras,

* It may here be worthy of notice, that throughout the Old Testament, as in all the writings of the Greeks and Romans, the word soul is used for life. "I shall require back your souls from the hands of both man and beast." (Leviticus.) In the following

Anaxagoras, and Democritus, was rejected by Plato, Aristotle, and the Stoics, who maintained that the different elements are mutually convertible into each other. Besides, the universal doctrine of the ancients, that all space is filled with subtile matter, is supposed to have been rejected by Epicurus, who is generally understood to have maintained the vacuum of space. ||

But with all due reverence for the wisdom of the ancients, it must be acknowledged, that they never fully established any one great principle in physics, capable of widely-extended application to the benefit of mankind. Many of their

lines from Homer's Iliad, translated by Pope, the living principle is represented as escaping with the blood:

> "The vital spirit issued at the wound,
> And left the members quivering on the ground."

And in the description of a dying hero by Virgil, the soul is identified with the blood :

> "Purpuream vomit ille animam."

|| Mason Good says, "it required 3000 years to render the doctrine of a vacuum probable, and 5600 years to establish it on a solid foundation. For its probability, we are indebted to Epicurus ; for its certainty to Sir Isaac Newton." (Book of Nature, vol. i. p. 343.) But the following lines from Lucretius, translated by Good, leave it doubtful whether any of the ancients ever believed in a perfect vacuum :—

> "The myriad seeds of fire dispersed at large
> Through all things, back to the same fountain flow ;
> And hence well forth o'er all the exulting world
> In boundless flood."

views were simple, ingenious, and grand; but their knowledge of natural history, including geography, geology, mineralogy, chemistry, botany, and comparative anatomy, was far too limited to form the basis of a comprehensive theory. And notwithstanding the high importance attached by the Greeks to the agency of fire in the phenomena of nature, they never made anything like a regular and systematic attempt to point out the laws by which it operates, in separating and recombining what they called the elements of air, water, and earth. Nor did Hippocrates explain the manner in which animal heat is derived from the atmosphere by respiration; how it is connected with fever, inflammation, and the various forms of disease. The same observation applies to all his successors, down to the time of Galen, against whom Bacon brought the heavy accusation, (which applies equally to the modern teachers of medicine,) that "he took away the infamy of ignorance in physicians, by declaring so many diseases incurable; thus paralyzing their exertions, cutting off the hopes of improvement, and proscribing the sick." It was therefore justly observed by this great reformer of science, that "inventions for enlarging the power of man over the university of things must be sought in the light of nature, and not in the dim shades of antiquity."

From the decline of Grecian and Roman civi-

lization, until the revival of learning in the 15th century, was a long dreary night of ignorance and superstition. The great book of nature, "writ by God's own hand," which speaks a language more instructive than that of men, was exchanged for the mystic jargon of the schools; and the voice of truth was drowned by the clamour of bigotry. But about this time a new era began to dawn upon the darkened world. By the reformation of Luther, the foundations of thought were renovated throughout Europe. The invention of gunpowder, the art of printing, and the directive power of the compass, did more to improve the condition of mankind, than all the united discoveries of antiquity. For the first time in the history of our race, the true theory of the solar system was established by Copernicus and Kepler. By means of the telescope a highway of communication was opened up with the heavenly bodies by "the starry Galileo," who demonstrated the annual and diurnal motions of the earth; for which he was denounced as the enemy of religion, and the propagator of false philosophy.*

For the first time in the history of science, the circulation of the blood was systematically established by the immortal Harvey, for which he was

* When summoned before the Inquisition for maintaining the motion of the earth, and required to give his reasons for such a heresy, he was answered by the commissary of the holy office, "Terra autem in eternum stabit, quia terra in eternum stat."

rewarded with persecution, accused of "confounding all medical theory, and of rendering physiology unintelligible." Truly may it be said, that prejudice is a frightful ogre, and bigotry a very fiend. Then arose Bacon with a holy zeal, and cried, "Only let men awake and fix their eyes one while on the nature of things; another while on their application to the benefit of mankind." The ghostly ministers of superstition had long denounced the knowledge of nature as dangerous; but Bacon showed it to be "more beautiful than any apparel of words that can be put upon it," and the true foundation of human happiness,—without which even religion is perverted into an engine of oppression and misery.

It is not my object to examine all the metaphysical, mechanical, and chemical theories of life, that have arisen and passed away since the time of Harvey. So vast are the troops of error, that to notice them all in detail would be an endless task. It would doubtless be far better to establish one important truth, than to refute a thousand errors; or, as Bacon observes, "to set up one great light, or branching candlestick of lights, than to go about with a watch-candle in every corner." Yet as it is necessary to know what has been done, that future inquirers may know what remains to be accomplished, I shall devote the remainder of this chapter to a brief review of the leading doctrines on which the modern systems of medicine have been founded.

Amidst the revolutions of empire, religion, and philosophy, that followed the decline of Grecian and Roman civilization, the establishment of Christianity, and the rapid diffusion of Mahometanism after the 6th century, the doctrines of the ancients in regard to the agency of fire as the ruling principle of nature, seems to have shared the same fate as that of the heathen mythology.* It is true that Harvey represents what he termed *calidum innatum* as the immediate cause of vitality in the blood, and of the heart's action. But so vague were his views of its nature and laws, that he describes it as something different from solar heat, or that of combustion; and sometimes called it the *natura naturans*, or the *facultas vegetativa.* (De Generatione, p. 170.)

The truth is, that nearly all the great writers of this epoch recognized the existence of an active principle in nature, as the cause of motion and organization, to which they gave different names; but without identifying it with any known agent. The *Archeus* of Paracelsus and Van Helmont was only another name for the πῦρ Νοερον of Pythagoras, Heraclitus, and Hippocrates; for they maintained that it was diffused throughout all

* Had knowledge continued to advance from the time of Cicero, Seneca, and Galen, until that of Bacon, Galileo, and Harvey, as it did from the epoch of Pythagoras, Hippocrates, Aristotle, Theophrastus, and Galen, the physical and moral condition of mankind would probably have been elevated as far above what it now is, as the civilization of modern Europe has surpassed that of the New Zealanders.

matter, and operated with consummate intelligence in the formation of mineral, vegetable, and animal bodies; that vital heat is generated in the blood by fermentation, through the agency of the animal spirits, derived from the air by breathing; that food is dissolved in the stomach by means of an acid liquor, and not by the agency of heat, because digestion is carried on in cold blooded animals, and arrested in man during fever—in short, that all the functions of life are governed by the immediate agency of an intelligent principle.*

The *pneumatical body* of Bacon was clearly derived from the πνευμα of the later Greek philosophers; for in his Treatise on Life and Death, he represents it "as the master workman of all effects in the living body;" while, in various other parts of his Natural History, he describes it as an imponderable spirit, and the *cause of evaporation*, germination, fermentation, putrefaction, &c. It is therefore evident that Bacon regarded it as the efficient cause of mechanical, chemical, and vital action. Yet, so far was he from recognising its identity with the elementary fire of antiquity, that he represents heat as

* This doctrine, which seems to have been almost universal among the ancients, has been recently revived by Isaac Taylor, who maintains that, in all cases, *mind alone is capable of putting matter in motion;* that it is the cause not only of muscular contraction, but of secretion, nutrition, &c. (Physical Theory of another Life.)

a mere effect, condition, or property of other matter. On the whole, his views of the animating principle were less accurate than those of Servetus and Harvey, who maintained that it was derived from the atmosphere by respiration, imparted to the blood in the lungs, giving it a bright florid hue, and as possessing the vigour of heat to produce motion.*

The *vital*, *natural*, and *animal spirits* of Descartes and his numerous followers of the 17th century, were identical with the πνευματα of Galen, to which he referred the faculties of generating animal motion, sensation, and intelligence, according to the different parts of the system in which they resided, as the thorax, abdomen, brain, &c. But so ignorant was Galen in regard to the source of animal heat, that he sometimes speaks of it as an inherent condition or property of living bodies, diffused from the heart through the arteries to all parts of the system, in connexion with the *pneumata*, or spirits; and he supposed that the principal object of respiration was to cool the blood. The same doctrine was taught by Silvius, Fabricius, Harvey, Bartholine, Swammerdam, Morozzo, and Cigna; while Borelli, Boyle, and many others belonging to the mechanical school, down to the time of Haller, maintained

* The same active principle was recognised by Dr. Henry More, as the *spirit of matter*, and by many other philosophers of that period as the *plastic* principle of NATURE.

that animal heat was produced by the motion of the blood, and friction of different parts of the body, because the temperature of animals is increased by motion and exercise.

The *æther* of Sir Isaac Newton, to which, in various parts of his later writings, he referred gravitation, cohesion, capillary attraction, the emission, reflexion, refraction, and inflexion of light, the elastic force of gaseous bodies, and the power of menstruums to dissolve solids, was identical with the Αιθερ of Orpheus, and the ancient sages of the East. He further suggests, in the Third Book of Optics, that " animal motion may be performed by the vibrations of this æther, excited in the brain by the power of the will, and propagated thence through the capillaments of the nerves into the muscles, for contracting and dilating them."

It is therefore evident that Newton did not always regard attraction and repulsion as ultimate phenomena, but that he referred all the operations of nature, including animal motion, to what he termed an " unknown æther," which I have shewn to be identical with caloric. Yet so imperfect were the views of this great mathematician in regard to the nature of heat, that he represents it as an *effect* of vibrations of the æther. Had he been aware that the velocity of the planets through their orbits is directly in proportion to the heating power of the sun, which

varies inversely as the squares of the distance, he would not have referred their lasting motions to a single impulse, exerted through a vacuum. Or had he known that the quantity of life diminishes from the equator to the polar regions, like all the mechanico-chemical transformations of matter, he would not have regarded comets as destined to supply the planets with vitality. But as he confounded the cause of motion, of climate, changes of season, the growth of vegetation, &c. with vibrations of an æther which he never identified with any known agent, it is not very surprising that his physical speculations have been little understood.

During the time of Newton, it was discovered by the experiments of Boyle, Hooke, Mayo, Bathurst, and Henshaw, that, during the process of respiration, a portion of atmospheric air underwent the same change as in ordinary combustion; by which its elasticity was greatly diminished, and its property of supporting life destroyed. Mayo supposed that a *nitro aerial spirit* was imparted to the blood in the lungs. But in accordance with the reigning fashion of the day, animal heat was referred to innate powers of the system, or to motion of the blood, its friction, against the solids, &c.

From the times of Homer, Hippocrates, Galen, and Celsus, down to the period of Harvey and Sydenham, the animating principle was sup-

posed to be conveyed to all parts of the system with the blood, which was thought to be the immediate source of all diseases. But after the attention of physiologists was awakened to the importance of the brain and nerves, by the researches of Willis, Malpighi, and others, it was maintained by Stahl, Hoffman, and Mead, that all the functions of animal life, whether vegetative or sentient, are immediately dependent on the nervous system; that some peculiar and refined species of fluid, which they regarded as identical with the animal spirits of the ancients, was *secreted by the brain, and conveyed to all parts of the body through the nerves.* It must, however, be confessed, that the *neuro physiologists* never explained what enables the brain to secrete; how the solids are formed from the blood; what endows the blood with the power of vitalizing all the organs; in what way the eggs of animals are hatched by nervous influence; nor how the life and growth of vegetables, including many of the lower orders of animals that have no nerves, are sustained.

Yet the celebrated Cullen was so pleased with the above fanciful hypothesis, that he represents the brain as necessary to the action of the vital principle, and the primary source of animal motion, whether voluntary or involuntary. He further maintained that all diseases should be referred to some preternatural condition of the nervous system; that cold, miasmata, fatigue, the de-

pressing passions, &c. diminish the vital energy of the brain, and through it that of all the other organs, causing debility and a spasmodic state of the capillary vessels, as in the cold stage of fevers. He further maintained that *the temperature of animals is in proportion to the quantity of their life, or nervous energy.* Yet he never explained how animal heat is generated by respiration; how diminished during the cold stage of fever, and increased during the hot; why fever is attended with nausea, headache, pains in the back, limbs, &c.; nor in what way spasmodic diseases arise from derangement of the nervous system. But I shall endeavour to make it clear in the following pages, that the brain is no more the origin of animal motion, than the rudder of a steam-vessel is the cause of its moving power; that as the object of the one is to guide the direction of the vessel, so is it the office of the other to generate ideas, or endow the living machine with sensation, intelligence, volition, &c.

In accordance with the Newtonian doctrine, that all the molecular changes of matter are owing to the innate powers of attraction and repulsion, Haller referred the phenomena of life to *irritability* and *sensibility*, the first of which was regarded as an inherent property of the muscular fibre, and termed *vis insita;* while the other was supposed to reside in the medullary tissue, and was called the *vis nervosa.* But if the muscular and nervous systems be not duly sup-

plied with living blood, the *vis insita* and the *vis nervosa* can have no existence ; nor can they be supported by the blood, unless the latter be vitalized by respiration. It is therefore evident that these fundamental properties of life are derived from the atmosphere, and not inherent in any part of animal bodies, whether solid or fluid.

With the most distinguished philosophers of ancient and modern times, it was maintained by John Hunter, that all the phenomena of animal life are governed by an independent principle, which he termed the *materia vitæ*, and sometimes the *architect* or *organ builder*. But so far was he influenced by the neuro physiology of Hoffman and Cullen, that in his Treatise on the Blood, he confounds it with the hypothetical nervous fluid, and even with the medullary substance. He says, " I consider that something similar to the materials of the brain is diffused through the body, and even contained in the blood, between which and the brain a communication is kept up by nerves : I have therefore adopted terms explanatory of this theory, calling the brain the *materia vitæ coascervata ;* the nerves *cordæ internunciæ ;* and that which is diffused through all parts of the body, the *materia vitæ diffusa*." (P. 89.) But, again : he observes that breathing seems to communicate life to the blood, which imparts it to all the other organs ; that as the brain and nerves are composed of

the same tissue, it is presumptive proof that nothing material is conveyed from one to the other; but that sensations and volitions are only a species of nervous action. So contradictory and unsettled were all his notions on this important subject, that he again represents "the stomach as the seat of the *materia vitæ*, and thereby the organ of universal sympathy;" to which he referred "the sensations of heat and cold that attend many diseases." In another place he confounds the organizing principle with "a certain species of motion," in the same way that Bacon, Rumford, and others, confounded heat with motion; or as the disciples of Sir Isaac Newton have confounded the cause of attraction and repulsion with *mechanical force*. To complete the problem of contradictions, Hunter finally observes, that "life is a *property* we do not understand."

In accordance with the doctrine of Cullen, who rejected Dr. Black's theory of respiration as the exclusive source of animal temperature, Hunter maintained that "*the degree of heat in animals is in proportion to the quantity of their life.*" (Phil. Trans. vol. 66.) But it might as well be said that the degrees of heat throughout the earth, from the equator to the poles, are in proportion to the quantity of animal and vegetable life. Had this great anatomist known that all the physico-chemical and vital operations that

make up the history of our planet, are directly in proportion to the heating power of the sun, he would have recognised caloric as the cause of motion, and as the grand instrument of the Deity in all the revolutions of matter—from the formation of mountains to the aggregation of crystals, and the more complicated organization of living bodies. Or had he known that the vital energy of animals is directly in proportion to their standard healthy temperature, he would not have inverted this fundamental law of physiology.

In the observations of Hunter on the animal economy, he recommends to the attention of philosophers a comprehensive inquiry into the laws of heat, as connected with all the operations of nature. And he observes in his Lectures on the Principles of Surgery, that "heat must be regarded as one of the first principles of action in nature, which unlocks matter, and allows it to act according to its natural properties; that it is congenial with the vital principle, which owes its vigour to a due supply of heat; that it is a sign of strength in the constitution, whereas coldness arises from weakness of the whole constitution."* But I have shewn that heat is not only the agent which unlocks matter,

* Following in the footsteps of Hunter, Sir Gilbert Blane observes, that "the combination of heat with the *conservative principle*, forms the main constituent of simple life." (Medical Logic.) But, like the *vis insita* of Haller, the *vis medicatrix*

but that it is the great bond of union, without which matter could have no power of action.

When commenting on Hunter's theory of life, Mr. Abernethy observes, that the widely extended research into all the phenomena of nature which the subject requires, is more adapted to an ancient Greek philosopher, than to one of the present day. He then declares himself at "a loss to know what chemists now think respecting heat—whether they conceive it to be a distinct species of matter, or mere motion; and that in this state of perplexity he could not advance one step further than Mr. Hunter had led him." Alas! that great man left the theory of life in almost as much obscurity as the chemists have left that of heat, light, and electricity; for notwithstanding his numerous experiments on the blood, he never explained the cause of its coagulation and conversion into the various tissues.

After the discovery of oxygen by Priestley and Scheele, Girtanner, Blumenbach, Richerand, and many other physiologists in different parts of Europe, including Dr. Southwood Smith and Dr. Holland, have maintained it to be "the life-sustaining principle of the atmosphere." But it is absolutely certain that oxygen exerts no influence whatever in maintaining the functions of

naturæ of Hoffman and Cullen, the *excitability* of Brown, the *sensorial energy* of Darwin, and the *nisus formativus* of Blumenbach, the conservative principle is a mere refuge for ignorance in regard to the physical cause of all the vital functions.

animal life, unless it undergoes a chemical change in the lungs, by which caloric is evolved and united with the blood. Besides, the quantity of life throughout the earth, is not in proportion to the amount of oxygen, which is even more abundant in the polar regions than in the climes of perpetual summer. It would therefore be a waste of time to dwell on the absurdity of regarding oxygen as the organizing principle independent of caloric.

When it was found that electricity is capable of causing the muscles of recently killed animals to contract, philosophers began to imagine that this agent was identical with the unknown nervous fluid, and generated in the brain, which some have represented as a galvanic battery.* Mr. Abernethy fancied that it was the *materia vitæ* of Hunter; while Lamarck supposed that the vital principle was composed of electricity and light. But it is not in the form of electricity that the solar fluid warms and vivifies the world. Nor is it in the form of electricity that

* In a recent work on the Principles of Medicine by Dr. Billing, the author maintains that "the contractile power of the different tissues is called into action by nervous influence, generated in the cineritious portion of the nervous system, and conducted by the white medullary part to all the organs; that it is *analogous to, or depends on, if not identical with the electrical principle, or fluid, whatever that may be;* that the energy of parts depends on a something communicated to them by the nerves, in conjunction with the brain and spinal marrow; causing the deposition of new, and the absorption of old matter, which keeps up a slow combus-

solar heat maintains the fluidity of the ocean, the mobility of the air, the transformations of chemistry, and the growth of vegetation; or that animal heat maintains the fluidity of the blood, the action of the heart, brain, and all the other organs. As I have already proved that caloric is the active principle in light, and that all the different forms of electricity are modifications of this universal principle, it is needless to dwell longer on the electrical theory of life.

From the earliest dawn of science in India, Chaldea, Egypt, and Greece, down to this period, the organizing principle was almost universally regarded as an independent, ethereal, and refined species of matter. Even the fathers of the church, including St. Ambrose, St. Hilary, Irenæus, Tatian, Tertullian, and others, maintained that there is nothing in nature, whether visible or invisible, which is not material; and that the soul, or animating principle, whether it inhabit the body or not, is of a corporeal nature. But since the publication of Sir Isaac

tion, and produces an extrication of caloric." (P. 17 and 20.) In other parts of the same work, he contends that all febrile diseases have their seat in the cineritious portion of the brain and nerves; and that convulsions have their seat in the white or medullary part of the same system, whether arising from excessive cold, irritation of the bowels, the action of narcotic poisons, the virus of a rabid animal, emotions of fear, wounds, &c.; that hydrophobia is a leaven which poisons the nervous system; and that the smallpox virus may produce its effect by some *chemical* or *electrical* action, positive or negative, on the nervous tissue.

Newton's Principia, Mr. Hume and several other philosophers have insisted that there is no such thing as a primary and efficient cause of power in nature, distinct from the phenomena produced; that cause and effect are resolvable into the mere antecedence and sequence of events; or that what is a cause in one case, is an effect in another. Dr. Thomas Brown observes, that men have not been able to discover the cause of gravitation, cohesion, and chemical affinity, because there is none except the inherent tendency of masses and their constituent particles to approach one another. But it might as well be said that there is no other cause of steam power than the inherent tendency of water to expand into the gaseous form, which is absurd, and contradicted by all experience. Besides, if it be true that caloric possesses the power of moving itself, and of generating motion in other bodies, it must be endowed with the essential attributes of a primary cause. And if when deprived of this principle the particles of matter become passive and motionless, it is clear that, without its agency, they could have no power of approximating, or of receding from each other.*

* So far as it was the object of Brown to guard men against the error of assuming the existence of some occult and immaterial cause of power in bodies, of which experience affords no proof, he was clearly right; for it must be admitted that all causes, whether material or spiritual, that exist in nature, must be a portion of this divine work. Newton carried this doctrine

Yet we are told by many of the most distinguished modern physiologists, that as Newton succeeded in resolving nearly all the phenomena of nature into the inherent properties of matter, there is no necessity of resorting to the agency of any distinct principle as the primary and efficient cause of animal motion. In accordance with this view, Bichat defines " life as the sum of the functions that resist death,"—Cuvier, as " the combined result of all the organic functions,"—and Richerand, as " the assemblage of the properties and laws that govern the animal economy." He says, " Le mot de principe vital, force vital, &c. n' exprime point un être existent par lui même, et indépendamment des actions par lesquelles il se manifeste: il ne faut l'employer que commune formule abrégé, dont on se sert pour désigner l'ensemble des forces qui animent les corps vivans, et distinguent de la matière inerte." *Nouveau Elémens de Phys.* tom. i. 80.

Here then, as Mason Good observes, " we have not only the employment of terms that have no

so far as to maintain the materiality of the *Great First Cause*; for, said he, " There can be no virtue without substance."—*Optics*, book iii.

But without transcending the limits of the human mind, it may be safely affirmed, that whoever denies the existence of any cause of attraction, repulsion, and animal motion, distinct from the phenomena produced, not only rejects the evidence of reason and the common sense of mankind, but involves the whole theory of nature in profound obscurity.

meaning, but properties, laws, and powers without any source,—a superstructure without a foundation,—effects without a cause."*

Similar views have been expressed by Magendie, who thinks that "physiology is now in the same condition that natural philosophy was before the time of Newton, and only waits until a genius of the first order shall arise to unfold the laws of vital force, as Newton did those of general physics." More than a hundred other writers might be quoted who have denied the existence of a vital principle, as maintained by Hippocrates, Aristotle, Galen, Celsus, Paracelsus, Servetus, Harvey, Van Helmont, Borelli, Perrault, Stahl, Hunter, Lamarck, and Abernethy; while a large majority of modern philosophers have, with an equal disregard of the clearest evidence, rejected the materiality of caloric, electricity, and light.

Dr. Pritchard objects to the doctrine of a subtile fluid as the cause of vital action, be-

* The truth is, that laws necessarily presuppose the existence of an agent; for they are merely the mode in which it produces effects in a regular or uniform manner. And it might as well be said that "murder is the act of murderously killing a man;" that "death is the process of dying;" that "opium induces sleep by means of a dormitive property;" that "the heart contracts by means of a pulsific virtue;" or that all the movements of nature are the sum of the powers that prevent it from falling into a state of quiescence; as that "life is the sum of the functions that resist death." It would be an abuse of reason to refute such vagaries.

cause he cannot conceive how it could produce the wonderful phenomena of animal motion, sensation, and thought, unless endowed with intelligence. This in reality was the opinion of Hippocrates, Galen, Seneca, and Virgil, who maintained that all the operations of nature were governed by the immediate agency of mind—"mens agitat molem." The same doctrine was taught by Paracelsus, Van Helmont, Harvey, and Stahl, who, with the ancients, seem to have identified the active principle in nature with the eternal mind of the universe.

The celebrated Baxter denied the existence of a subtile fluid as the cause of crystallization and planetary motion, because he could not conceive how it could produce such effects, unless it knew what it was about. (Immateriality of the Soul, p. 117.) He therefore maintained the vacuum of space, and referred all the phenomena of nature to the immediate agency of the Deity. Whether it be more in accordance with reason and piety to believe that all the mechanical, chemical, and vital changes of matter are effected by the immediate influence of the Supreme Creator, or by the delegated agency of physical laws, I leave to the common sense of mankind.

From the foregoing brief history, we may readily comprehend why no modern system of medicine has maintained its credit above fifty

years. Like the house in the parable that was built upon the sand, they have been defective at the very foundation, which, not being able to uphold the superstructure, they have gradually crumbled away, to be replaced by others destined to share the same fate.

The observation of Bacon is no less applicable now than it was two hundred years ago. "Medicine is a science which hath been more professed than laboured, and yet more laboured than advanced; the latter having been, in my judgment, rather in circle than in progression; for I find much iteration, but small addition." Mr. Whewell affirms in the last chapter of his Bridgewater Treatise, that "we have yet to begin to learn all that we are to know concerning the ultimate laws of organized bodies." And he observes in his late History of the Inductive Sciences, that "many anatomical truths have been discovered, *but no genuine physiological principle;* that the notion of life, and of vital forces, is still too obscure to be steadily held; and that we cannot connect it distinctly with severe inductions from facts, that we can trace the motions of fluids, as Kepler traced the motions of planets; but when we seek to render a reason for these motions, like him we recur to terms of wide and profound, but mysterious import—to virtues, influences, and undefined powers." (Vol. iii. pp. 404, and 431.)

CHAPTER II.

"Nil turpius physico, quam fieri sine causa quidquam dicere."
CICERO.

"The ultimate purpose of our researches is to penetrate and lay open the secret springs by which the great system of organization, termed nature, is maintained in a state of perpetual activity.—LAWRENCE.

THE prevalent doctrine of modern physiologists, that the phenomena of life are wholly distinct from those of inorganic matter, has arisen from our imperfect knowledge in regard to the primary physical cause of motion throughout nature; and is refuted by the fact, that the organizing power of the earth, like all the mechanical and chemical transformations that modify its surface, is directly in proportion to the quantity of caloric which it receives from the sun. For we have already seen that as the amount of evaporation and rain, the magnitude of rivers, the number of volcanoes, and the elevation of mountains diminish from the equator to the regions of lowest mean temperature; so do the number, variety, and magnitude of organized beings. Let us then reject the notion of Bichat, that "Physics are not accessary, but foreign to the science of physiology." (Life and Death, p. 83.)

It was observed by the learned Tiedemann, that "the final cause of vital force, like that of attraction, repulsion, gravitation, cohesion, and chemical affinity, is a secret whose profundity we shall never be able, from all appearances, to reach." (Compar. Physiology, p. 193,) But we have seen that without the union of caloric with the particles of ponderable matter, they could have no powers of approaching to, or of receding from each other; and that the entire extinction of solar radiation, if such a thing were possible, would put an end to the sublime revolutions of the heavenly bodies, together with all that is beautiful and glorious in the visible creation.

The celebrated Müller observes in a late work on the Elements of Physiology, that our knowledge of the vital principle is not more imperfect than it is with regard to the nature of caloric, electricity, and light; and that the cause of crystallization is no less difficult to comprehend than that of organization. But I have shewn that caloric is a self-moving agent, and the active principle in light, as in every form of electricity; that it depends wholly on the amount of caloric in bodies whether they exist in the solid, liquid, or gaseous state; and that the crystalline form of salts, rocks, &c. is greatly modified by temperature, as in the phenomena of *dimorphism*. Nay more, that there are many bodies composed of *the same elements in exactly the same proportions*,

which exhibit perfectly distinct properties when united with different proportions of the same active principle that transports their particles from one place to another, and arranges them in symmetrical forms; that gallic acid is converted into pyro-gallic acid by the addition of heat alone; and the latter into another distinct substance by a further addition of caloric, as in the formation of isomeric bodies.

It has been asserted by innumerable writers on physiology, that the phenomena of life are as far removed from those of ordinary chemistry as the latter from mechanics. But the Great Architect of the universe has so completely connected all the operations of nature together, that it is often difficult to draw the boundary line between mechanical, chemical, and vital action. The mechanical force of steam is generated by the chemical union of caloric with the particles of water, to the expansion and contraction of which we are indebted for all the phenomena of evaporation and rain, the nourishment of vegetation, and the sustenance of animal life.* The circulation of sap through the vessels of plants is no less the result of attraction than the absorption of water by a sponge, or its elevation in the ca-

* And if it be true, as there is every reason to suppose from analogy, that solar light, like that of a lamp or common fire, is generated by combustion, all the phenomena of nature must be referred to chemical action.

pillary tubes of dead matter; but with this difference, that the force is much greater in living vessels, owing to their extreme minuteness, compared with artificial tubes. The conversion of sap into organic molecules, and the latter into woody fibre, bark, leaves, flowers, fruits, and different secretions, is no less the result of attraction than the generation of water, salts, rocks, and other chemical compounds.

The first process of germination consists in a chemical fermentation in the seed, by which a portion of its substance is converted into sugar and carbonic acid, while another portion is changed into living organic molecules, that are arranged in symmetrical order, corresponding with the parent type from which it sprung. The generation of confervae and animal infusoria, during the putrefaction of organic matter, is no less the result of attraction than the conversion of sap into trees, and blood into the structure of animals, whether produced from seeds and eggs, or without the concurrence of parents, as maintained by Needham, Priestley, Ingenhouz, Monti, Wrisberg, Tiedemann, Müller, Treviranus, and many other distinguished philosophers. The same is true of the different species of entozoa found in the liver, brain, eyes, veins, and other parts of warm blooded animals, which seem to be formed by the immediate combinations of morbid secretions in the parenchyma of their organs, according to

the observations of Pallas, Müller, Treviranus, Rudolphi, and many others. But caloric is no less essential to fermentation, germination, circulation, nutrition, or the generation of microscopic plants and animals from the proximate constituents of dead organic matter, than to the combinations of ordinary chemistry.

So far as digestion depends on the solvent power of gastric juice, it is a chemical process, by which dead matter is converted into chyme. And that it is owing chiefly to the agency of caloric, would appear from the fact, that the digestive function in all animals is performed with a rapidity exactly in proportion to their mean healthy temperature, being greater in birds than in mammalia, and very much greater in both than in cold blooded animals, which require many days, and some of them several weeks to digest a single meal. We also learn from the experiments of Spallanzani, that the solvent power of gastric juice when taken from the stomach increases from 50° to 120° F.; and from the late researches of Dr. Beaumont, that when put in vials and kept at the temperature of 100°, it converted food into a species of chyme that could scarcely be distinguished from what was formed in the stomach, but required a longer time to produce the effect. The fact is, that cooking may be regarded as the initiatory process of digestion; for it is not only the softening of raw animal and

vegetable matter by the action of fire, and thus preparing it for entering into new combinations in the living body, but greatly changes its taste, odour, and other sensible properties.

The all-important function of respiration, so essential to animal life, is, strictly, a chemical process, by which a portion of atmospheric oxygen unites with carbon to form carbonic acid, with an evolution of caloric. Who then can say at what precise point the operations of chemistry are merged in the affinities of life, as in germination, spontaneous generation, the nourishment of plants, &c.; or when the latter terminate in the actions of ordinary chemistry, as during the ripening of fruits?

There is nothing more calculated to excite our admiration of the infinite wisdom by which the universe is governed, than the intimate relation that exists between all its physico-chemical and vital operations. By the mechanical diffusion of water through the atmosphere, organized bodies are supplied with the greatest part of their substance. The carbonic acid generated by chemical action during the processes of combustion, fermentation, and the respiration of animals, affords nourishment to plants—being decomposed in the tissue of their leaves, where crude sap is converted into cambium by the evaporation of water, and the absorption of carbon; then into starch, sugar, oils, &c. which in

their turn become the appropriate nourishment of animals. It was justly observed by Sir Charles Morgan, that " the distinctions which the subtilizing genius of man has invented to separate and to isolate, are contradicted and deranged at every new step of successful investigation." (Philosophy of Life, p. 62.)

Ultimate Elements of Organized Bodies.

Among the fifty four undecompounded bodies, independent of the imponderables, that form the crust of the earth, nineteen have been found in plants and animals, ten of which are non-metallic, and nine metallic ; viz. oxygen, hydrogen, nitrogen, carbon, phosphorus, sulphur, chlorine, iodine, bromine, fluorine, potassium, sodium, calcium, magnesium, silicium, aluminum, with the more ponderous metals, iron, manganese, and copper. *But the most remarkable circumstance connected with the chemical constitution of organized bodies is, that they are composed chiefly of the most light, active, and mobile species of matter, such as oxygen, hydrogen, nitrogen, and carbon, the three first of which are always found in the gaseous state, when not united chemically with other bodies; while their elasticity is such that no mechanical pressure has ever yet been sufficient to overcome it.* Hence it is that the atmosphere, and the waters that are elevated from the ocean, which are composed of these elements, are in a

state of perpetual motion, circulation, and chemical combination with other bodies.* These, with carbon, are the basic constituents of organized bodies; for the sum of the remaining fifteen does not exceed two or three per cent. And that the staminal elements of organic matter contain a larger amount of caloric around their particles than an equal weight of any other known bodies, might naturally be inferred from their tendency to assume the fluid state, their highly inflammable properties, their general activity, and from the enormous amount of heat evolved during their combustion.

On the other hand, the leading characteristic of the mineral world is, that it is composed chiefly of metallic bases, which are not only the most dense and gross, but the most inert descriptions of ponderable matter. The consequence of which is, that at all ordinary temperatures of the atmosphere, they remain solid and quiescent, while "the moving waters and the invisible air," are continually circulating throughout the earth, as if impelled by some spiritual agent. But if submitted to the influence of intense heat, the most refractory bodies are changed to the fluid state, (the essential condition of which is mo-

* It was long ago said by Aristotle, that the lightest descriptions of matter are the most perfect, and partake the nature of forms. As a proof that this is actually the case, it may be observed that the variety of organized species, which are composed of the lightest elements, is far greater than that of mineral bodies.

bility), and acquire the power of entering with great rapidity into new combinations, as in the regions of subterranean chemical action, where the rocks that form the solid mountains of the globe are aggregated,—and among the ruins of which have been discovered nearly all the precious metals and gems, including the rich and sparkling diamond. The metallic elements, united with various proportions of oxygen, hydrogen, nitrogen, carbon, &c., constitute the massy frame-work of the earth; but they are wholly incapable of forming organic compounds, and of executing the more elevated functions of living matter. It is therefore obvious that there is a broad line of demarcation between the chemical constitution of mineral and organized bodies.

Another fundamental difference between them is, that, with the exception of oxygen, hydrogen, carbon, and nitrogen, all the other elements of ponderable matter are capable of entering into simple binary combinations only; whereas the ultimate principles of organic bodies possess the additional power of forming ternary and quaternary compositions. Thus oxygen with hydrogen produces water; with sulphur, phosphorus, nitrogen, carbon, &c., it forms acids which are single binary compounds.* With

* Oxygen enters into the composition of nearly all bodies. It constitutes $\frac{1}{5}$th of the atmosphere, $\frac{8}{9}$ths of all the waters, and

calcium, sodium, potassium &c., it makes alkalies that are also binary combinations, which, on uniting with the above acids, form neutral salts, that must be regarded as double binary compositions; while the union of the same acids with simple bodies, such as the pure metals, gives a third order of binary compounds, according to Berzelius.

But in the formation of the simplest plant, it has been found that at least three elements, oxygen, hydrogen, and carbon, are united together in a direct manner, without any previous binary combination; and that the various tissues of all animals (if we except the very lowest species of zoophytes, the real character of which is doubtful,) are formed by the immediate union of the same elements with nitrogen. From the ternary and quaternary combinations of these active principles in various proportions, are generated all the diversified organizations that make up the living world, as shewn by the analytical researches of Thenard, Gay Lussac, Berzelius, Prout, Thomson, Saussure, Berard, Chevreul, Ure, and others. (Tiedemann's Comparative Physiology, p. 6, 7.)

about $\frac{1}{3}$rd of the solid earth. But as in the latter case it is chained down in a state of chemical combination with metallic and other gross matters, its active powers are kept in abeyance. It also forms about $\frac{7}{8}$ths of animal bodies, and above $\frac{2}{3}$rds of plants, as may be readily ascertained by a reference to their elementary composition, and the relative quantities of water in each.

But in addition to the power of oxygen, hydrogen, carbon, and nitrogen, to form ternary and quaternary compounds, it is worthy of special notice, that many more atoms of the same elements unite together in forming organic combinations than are found in those of inorganic bodies. For example, water is composed of one atom of oxygen to one of hydrogen; carbonic acid, of carbon one atom to two of oxygen; and so of innumerable other binary compounds; whereas the acid, saccharine, oily, and resinous constituents of plants, are generated by the immediate union of many oxygen, hydrogen, and carbon atoms. Starch is composed of seven atoms carbon, six of oxygen, and six of hydrogen; sugar of twelve atoms of carbon, eleven of oxygen, and eleven of hydrogen; while the oil of peppermint consists of carbon atoms ten, hydrogen ten, and oxygen one. The resins and fixed oils contain still higher numbers of the same atoms, as may be seen by referring to p. 146 of the First Book, where it has been shewn that this constitutes the principal difference between the volatile and more tenacious compounds of organic matter. From which it is probable that the quaternary unions of oxygen, hydrogen, carbon, and nitrogen, to form the proximate constituents of the blood and solid tissues of animals, contain still higher numbers of atoms of the same elements. So that

whether the affinities of life be owing to the same physical cause which governs those of inorganic matter or not, the former evince at once a far more complex and refined mode of operation. Hence the beautiful remark of Kielmyer, as cited by Tiedemann, that crystallization represents in some degree the simple elements of geometry; while in the production of organized bodies, nature has employed a high geometry.*

Owing to the more complex affinities by which the elements of organized bodies are joined together, they have a greater tendency to undergo what has been called spontaneous decomposition, than the binary combinations of inorganic matter. And it would seem to be a general law of nature, that *the force with which bodies cohere together, is inversely as the number of elements and atoms of which they are composed.* For example, water is more difficult to decompose than the deutoxide of hydrogen; carburetted hydrogen, than bicarburetted hydrogen; and the latter thanætherine. In like manner, the protoxide of nitrogen is more difficult to resolve

* It may here be observed that saccharine bodies, including gum, starch, lignin, tannin, &c., are formed by the union of oxygen and hydrogen in the proportions that form water, with carbon; that the same elements with oxygen in excess form acids; while with hydrogen in excess, with respect to oxygen, they afford oily and resinous compounds. Yet there is a large class of acids that contain no oxygen, such as the hydrocyanic, the hydrochloric, &c.

than the deutoxide; and so on till we come to nitric acid, which is composed of five atoms oxygen to one of azote, and may be decomposed with great facility. But I have shewn that the quantity of caloric around the particles of alcohol, æther, nitric acid, &c., is in proportion to the number of atoms that enter into their composition, *cæteris paribus*. It is therefore not true, that the disposition of organized bodies to run into new combinations is owing merely to their elements not being united in definite proportions, or to their not being saturated, as maintained by Tiedmann and others; for the elements of sugar, alcohol, and many other similar compounds, are as completely saturated as those of water, carbonic acid, or the earths and alkalies, which are so difficult to decompose.

Corresponding with the simple binary composition of minerals, they are of uniform structure throughout; and when once formed, their individual existence depends on the repose of their particles. What they are when first aggregated, they remain until destroyed. They may be enlarged by accretion, and diminished by attrition, but they have no organs of nutrition, secretion, or reproduction; no origin by birth, no renewal of their composition, and no termination by death. Being composed of the more ponderous elements, or binary combinations of them, they

are held together with great force, and endure for a much longer time than trees, which consist of ternary combinations of more active elements. For the same reason, animal bodies that are formed of three elastic gases, united in various proportions with carbon, are more volatile and destructible than wood, after the affinities of life have ceased. In other words, minerals are more solid and fixed than plants, because they are formed of more gross and inert materials; while trees are more solid and durable than the animal tissues, because the first are composed chiefly of water, with carbon, and the latter of air, water, and carbon.

So essential are fluids to the existence of organized bodies, that they constitute nearly the whole of their substance during the embryotic state, especially in the egg and fœtus of animals. But the proportion of fluids to that of solids, varies in different species, and at different periods of their growth, being about ten to one during early life in the human body, and six to one in old age. According to Richerand, they are as three to one in trees; but they are much more abundant in the annual and more succulent plants, as also in the newly formed parts of trees; while it is worthy of notice, that the affinities of life are always most active in those parts which receive the greatest amount of fluids, such as the medullary and muscular tissues of

animals, and the soft vascular structure of plants; but that the movements of life are slow and feeble in the hard woody fibre, and almost wholly absent in the earthy matter of bones. *Fluidity*, then, which is only another name for *mobility*, is absolutely essential to the manifestations of life.

According to the latest analyses of human venous blood, it has been found to consist of about 790 parts of water in 1000, and the remainder of albumin, fibrin, colouring matter, oily and saline ingredients. From which it is obvious that as water is composed of eight parts by weight of oxygen to one of hydrogen, and also forms about $\frac{1}{3}$ of the organized part of the blood, oxygen must constitute by far the greater proportion of its substance; the remainder being carbon and nitrogen, with nearly 1 per cent. of saline matter.

From the ternary and quaternary combinations of oxygen, hydrogen, carbon, and nitrogen, organic molecules are generated, which form the proximate constituents of all living bodies, whether fluid or solid, from the simplest plant or gelatinous animalcule up to man. They have been found in the blood, chyle, chyme, milk, fat, saliva, bile, pancreatic, and gastric juice, the seminal fluid, the yolk and albumin of the egg, in all animals; in the sap of plants, and much more abundantly in the cambium,

after it has been exposed to the influence of solar warmth while circulating through the leaves. They have also been discovered in the albumin of farinaceous seeds and bulbous roots, the cells of flowers, and the embryo while forming, according to many accurate observers, cited by the learned Tiedmann. As might naturally be supposed, these globules, as they have been termed, vary in form, colour, and magnitude, according to the species to which they belong, and the office they are destined to fulfil.

By the arrangement of organic molecules, in series and aggregates, the primary tissues of all living bodies are generated, in accordance with laws no less fixed and definite than those of crystallization. The lowest species of plants and zoophytes, such as fungi, lichens, algæ, and the gelatinous animalcules, are composed chiefly of cellular tissue, which in the higher orders of plants is expanded into ligneous fibre, bark, leaves, and flowers. The cellular tissue also enters so largely into the composition of the more perfect animals, that it has been often represented as the scaffold of all the organs, and the mould in which their particles are deposited. The osseous, cartilaginous, fibrous, vascular, serous, dermoid, and mucous membranes, are all regarded as modifications of this primary tissue, which is formed chiefly of albumin, arranged in lamellæ and fibres variously interlaced, so as to

constitute a net-work of cells, that communicate with each other throughout the body.

But as the elementary composition of animals is more complex than that of plants, they present a more diversified system of organization, if we except the lowest species of zoophytes, which so nearly resemble the simpler microscopic plants, that some physiologists have maintained their mutual convertibility into each other. For example, in addition to cellular tissue that forms the basis of plants, and the principal portion of the higher animals, the latter are composed of *muscular and nervous* tissues, by which they are endowed with the powers of locomotion, perception, and consciousness. The muscular fibres are formed of fibrin, the particles of which have been said not to exceed the 40.000th part of an inch in diameter, and are arranged in lines that resemble rows of globules under the microscope; while the nervous tissue is composed of albumin, and certain oily matters that contain much hydrogen, and a little phosphorus, forming an infinite number of exceedingly minute and delicate tubes. (Müller's Elements of Physiology, p. 599.)

By the union of these three primary tissues in various proportions, the different complicated organs of the animal fabric are built up, as the heart, stomach, intestines, liver, pancreas, kid-

neys, muscles, ligaments, tendons, cartilages, membranes, bones, &c.; all of which are generated from the albuminous, fibrinous, oily, and saline constituents of the blood; which is formed by the immediate union of oxygen, hydrogen, carbon, and nitrogen, into quaternary combinations. Most of the fluids secreted by animals, such as gastric juice, bile, mucus, pancreatic and seminal liquor, are also quaternary compounds. But they also secrete several combinations that are ternary, as the sugar of milk and urine, fat, resin, and the volatile oily matters termed civit and castor. On the other hand, there are many plants that contain nitrogen, which is abundant in mushrooms, and has been recently discovered in the vegetable salifiable bases, as morphine, narcotine, veratrine, solanine, delphine, emetine, quinine, cinchonine, pollenine, and some other like compounds. From which it is obvious, that the more complicated organization of animals than of plants, is not owing merely to the greater complexity of their elementary composition, as will further appear hereafter. Yet there cannot be a doubt, that the structure and functions of all organized bodies are determined by the chemical constitution and fundamental properties of their ultimate elements, which are modified by every increase or diminution in the quantity of caloric around their atoms.

Now the great question that lies at the very foundation of organic chemistry is, whether the power of forming ternary and quaternary compounds, with the aptitude for renewing their composition by assimilation and elimination, be owing to the same cause which governs the affinities of dead matter, or to some peculiar principle of a totally distinct nature, as maintained by Berzelius, Tiedmann, Müller, and nearly all the most distinguished physiologists of the present day? Nothing but an earnest appeal to nature, and a careful examination of facts can resolve this difficult problem.

The learned Tiedmann observes very justly, that the difficulty of explaining the phenomena of life by the laws of physics, may be owing to our imperfect knowledge of natural phenomena in general. But Müller contends, that "the power by which the elements of organized bodies are united into ternary and quaternary compounds in opposition to the laws of chemistry, is, without doubt, a peculiar force, or imponderable matter, unknown in inorganic nature." Yet he admits in another place, that the cause of crystallization is not more profoundly hidden than that of organization. (Elements of Physiology, pp. 22, 251.) That the power of oxygen, hydrogen, carbon, and nitrogen, to form the proximate constituents of living bodies, is owing to the fundamental properties of these elements,

would appear from the fact, that no others are capable of entering into ternary and quaternary compositions; in short, that no plant or animal was ever formed or nourished by any other elements. And that the tendency of dead organized bodies to undergo decomposition, is owing to the same active principle that enables these elements to form ternary and quaternary combinations, is proved by the circumstance that this tendency is augmented by every addition of caloric, which I have shewn to be not only the universal bond, but the great decomposer of all matter.

During the decomposition of organized bodies under the influence of a summer temperature, a portion of their substance enters into binary compounds of water, carbonic acid, and ammonia. But during this process, another portion of the same elements unites to form the simplest species of microscopic plants and animalcules, without the concurrence of parents, seeds, eggs, or the addition of any other principle than was concerned in the generation of water, carbonic acid, &c. And as it has been shewn that the form of crystals depends on the nature of their atoms, modified by the temperature at which they are aggregated, so has it been observed that the specific character of infusoria, generated during the fermentation of albumin, fibrin, starch, gluten, and other organic compounds, varies ac-

cording to the different species of matter employed. Those simple organizations termed entozoa, generated in the parenchymatous substance of many animals, without the visible existence of any parents, eggs, or germs, also vary according to the nature of the animal, and even of the organ in which they are formed.* Nor is there anything more mysterious in this, than in the ordinary process of generation, only that we are more accustomed to the latter; or that specific contagions should be generated by certain combinations of filth, and vitiated animal secretions, as in gonorrhea, lues venerea, small pox, the itch, &c., that have the power of propagating themselves in a mode analogous to the production of fermentation by yeast; which,

* It is said that twelve different species of entozoa have been found in man, six in the alimentary canal and its appendages, one in the lungs, one in the brain, one in the eyes, one in the muscles, one in the kidneys, one in the ovaries, and one in the skin: while in the several organs of the sheep, nine species have been discovered; eleven in the ox; nine in the horse, hog, and fox; and eight in the hare. They have been found in birds, reptiles, fishes, crustacea, and mollusca. (See Fletcher's Rudiments of Physiology, part ii. p. 12.)

They have also been found in the embryons of these animals; from which it is maintained by Pallas, Müller, Werner, Bloch, Goeze, Braun, G. R. Treviranus, Rudolphi, and others, that they are the products of non-assimilated matters, or morbid productions formed in the humours or parenchyma of the organs, in a mode resembling the generation of infusoria during the fermentation of organic matter. (Tiedmann's Comp. Physiology, p. 40.)

according to the observations of De la Tour, is composed chiefly of organic molecules that have the faculty of multiplying themselves in all fermentable matters.

Should it be objected that such molecules, like the different species of moulds, confervæ, and animalcules, can be generated only from matter that has been once organized, I answer that the elements of oxygen, hydrogen, carbon, and nitrogen, wherever they exist, are capable of entering into the universal tide of life; whether locked up with rocks, metals, and beds of coal, in the bowels of the earth, or floating over its surface in the state of air and water. When once formed, the germs of plants have the power of converting the binary combinations of water and carbonic acid into ternary compositions of lignin, sugar, starch, and other organic products, which are thus prepared for entering into the composition of more exalted species of organization—while it is certain, that whatever the cause of vital action may be, it is incapable of converting the elements of mineral bodies into the sap, cambium, and solid structure of plants; or into chyme, chyle, blood, and the different organs of animals. Owing to the comparative inertness of their elements, mineral bodies have the power of entering into binary combinations only, which maintain their original state of aggregation until destroyed by chemical agency, and

possess no internal mechanism for renewing their composition. But the essential attribute of the elements of organized bodies is that of *mobility or activity*, by which they are kept in a state of perpetual transformation, or transition from death to life, and from life to death.

> "All forms that perish, other forms supply,
> By turns we catch the vital breath and die."

Owing to the large amount of caloric around these elements, they are enabled to form ternary and quaternary combinations, *with the aptitude for life;* and when reduced to the condition of dead matter, they are constantly entering into binary combinations of water, carbonic acid, &c., or into the simplest forms of living organizations. But if reduced to a low temperature, all their chemical and vital affinities cease, when they assume that condition of repose which characterizes the elements of mineral bodies. The sap of plants is no longer converted into cambium, lignin, bark, leaves, flowers, and fruits. The food of animals is no longer converted into chyme by uniting with gastric liquor; into chyle by uniting with bile and pancreatic juice; nor into blood during the pulmonary circulation. But when the temperature of the human body is maintained by respiration at the normal standard, it exhibits a universe of motion in miniature. Like the waters of the earth that are continually passing from the ocean by

evaporation, and returning to their source by rivers, the blood is conveyed with immense rapidity from the lungs and heart throughout the system, renewing its composition by the deposition of fresh organic molecules, the cohesion of which diminishes until the cause of force is expanded by action; when they are removed by absorption, conveyed into the general circulation, and thence out of the body by elimination. Not a particle remains quiescent for any considerable time, so that in about forty days, a complete revolution is supposed to be effected in its substance, if we except the cartilages, bones, and teeth, the last two of which are almost wholly destitute of life. The cellular tissue is also endowed with a very low degree of vital energy, compared with the nervous and muscular, if we except the mucous membranes; and contains much less nitrogen in its composition.

That the power of living bodies to renew their composition by assimilation, and to reproduce their species by generation, is governed by the emphatic agency of caloric, is evident from the fact, that the power of nature to multiply organic forms, is directly in proportion to the temperature of the earth, from the equator to the polar circles. It is only in the regions of perpetual summer, that the number of species, variety of structure, and magnitude of form, are developed in full perfection throughout the vegetable world—where

the air is perfumed with the odours of myrrh, balm, frankincense, sugar-cane, coffee, tea, mace, cloves, nutmeg, cinnamon, pepper, with innumerable other plants that abound with the most highly elaborated aromatics and precious drugs—where the fig-tree, orange, lemon, date, and a thousand varieties of palms, are loaded with an exuberance of delicious fruits. But as we advance to the middle latitudes, where the mean temperature is from 20° to 30° lower, we find that the more exquisitely organized vegetation of the torrid zone is, for the most part, replaced by totally different orders and genera, which diminish in number, variety, and magnitude, on to the polar circles; where only fungi, lichens, algæ, the humbler grasses, and a few other plants of the most simple structure are generated during their short summer.

It is also in the tropical regions, that animals have been found in the greatest number, and where they arrive at the greatest magnitude; from the ostrich, cassowary, and condor of Africa and South America among birds, to the elephant, rhinoceros, hippopotamus, giraffe, and camel, among mammalia, or the gigantic species of the feline tribe, as the lion, tiger, leopard, &c. But it is more especially among cold blooded animals, that the magnitude of the same species is found so greatly to exceed that of such as inhabit the higher latitudes. The developement of the cro-

codile, boa, anaconda, the immense turtles of the East and West Indies, as of the enormous mollusca of the tropical seas, and the mighty forests of India, Africa, and South America, is fostered by the ceaseless influence of a powerful sun.

If the whale and a few other mammalia attain to a great size in high latitudes, it is because they are supplied with an apparatus for obtaining caloric from the atmosphere by respiration, which maintains their mean temperature about 20° above that of the earth under the equator, as will be noticed further hereafter. The caloric thus acquired is preserved by means of a warm fur coat, or a subcutaneous layer of fat, that in the whale varies from eight to fifteen inches in thickness. And if there be some species of plants that remain evergreen throughout winter, it is because they abound with oily and resinous matter, which retains a sufficient amount of heat to prevent the destruction of their foliage, but not to maintain their growth.

Now whatever the cause may be by which organized bodies are enabled to renew their composition, must determine the actions that modify their structure and functions; for the elements of which they are formed are the same in all parts of the world, with this prominent exception, that within the tropics they are continually receiving from the sun a larger pro-

portion of that æthereal principle, (whatever men may choose to call it,) which preserves all nature in a state of activity. The elements of the air, water, and crust of the earth are the same in South America as at Melville Island; which is also true of all the plants and animals that inhabit the earth. The number of species, the magnitude of their forms, and complexity of organization, must therefore be regulated by the energy of the principle that causes their developement, which diminishes from the hottest to the coldest parts of the globe; because in the former, the affinities of life are continually in action, but suspended for six or nine months every year, in the middle and higher latitudes.

The experiments of Decandolle on the medicinal properties of plants, compared with their external forms and natural classification, prove that their composition depends on the vital energy by which they are developed. From which it follows, that if the phenomena that constitute their growth depend on climate, it must determine the composition of all their diversified products. If the indigenous plants and animals of the old world are different from those of the new in the same latitudes, there is a corresponding difference of mean temperature, which is generally higher in Europe and Asia than in North America. And if the vegetation west of the rocky mountains be different from

that of the same parallels west of that great chain, it is because the climate of the Western coast of America is greatly modified and improved by its vicinity to the Pacific ocean. Owing to the unequal distribution of land and sea, mountains, hills, plains, and valleys, there is an endless diversity of climate, with a corresponding variety of organized beings.

Theory of Respiration, as connected with Animal temperature.

Nothing could afford a more striking proof that "no genuine physiological principle has ever yet been discovered," than the numerous contradictory hypotheses now prevailing in regard to the source of animal temperature; some maintaining with Black, Crawford, Lavoisier, Ellis, and Dalton, that it is evolved in the lungs during respiration, by a chemical process, as in ordinary combustion; others with Bichat, that "it is a product of all the vital functions." (Life and Death, p. 278.) Within the last twenty years, many have embraced the theory of Sir Benjamin Brodie, who inferred from his own experiments, that animal heat is in some way generated by nervous influence, because mechanical injuries of the brain and spinal marrow were followed by a reduction of temperature.

But it is now certain that such injuries, like the influence of narcotic poisons, diminish or destroy the function of respiration; and it has been proved by the experiments of Hastings, Holland, Flourens, and many others, that the reduction of temperature may be greatly retarded by artificial inflation of the lungs after decapitation, and division of the 8th pair of nerves.

Others maintain, with Dr. Philip, that animal heat is the result of secretion; while Tiedmann contends that its evolution is "a vital act, which depends immediately on the process of nutrition, the conditional and preservative cause of life." (Compar. Physiology, p. 247.) Mr. Mayo says, that physiologists at present incline to the opinion that "the production of animal heat depends on nervous influence;" but without explaining how and whence the nervous system obtains it: and he adds in another page, that "the source of vital heat is unknown." (Physiology, pp. 79, 264.)

With Dulong and Despretz, Dr. S. Smith regards respiration as the principal source of animal temperature, but thinks there is reason to believe that the remainder is extricated from the blood by nervous influence, as in the processes of secretion and nutrition. (Philosophy of Health, vol. ii. p. 153.) Chaussat concludes, from his own experiments, that the evolution of heat depends more on the cervical portion of the spinal marrow or medulla oblongata, than on the brain. (Ann.

de Chim. et de Phys. t. iii.) And Müller observes, that "since all organic processes are dependent chiefly on nervous influence, it cannot appear wonderful if the reciprocal action between the organs and the nerves is a main source of animal heat." (Elements of Physiology, p. 86.)

As if with a view of reconciling these conflicting hypotheses, Dr. W. F. Edwards maintains, in a recent article on Animal Heat, contained in the Cyclopedia of Anatomy and Physiology, that it depends first, *on the condition of the blood; secondly, on the developement of the nervous system; and thirdly, on muscular contraction;* because the temperature of animals is in proportion to the richness of their blood, and the degrees of nervous energy, muscular power, &c. At the commencement of the same article, he observes, that "Physiologists have not been able to discover the cause of animal heat, for the same reason that natural philosophers have not yet discovered how heat is produced in the inorganic world." But if it be true that caloric is absolutely everywhere present, either in a combined or separate state, and cannot be traced to any more comprehensive principle, it must be allowed to possess the essential attributes of a primary physical cause. Moreover, I have proved that it has the power of moving itself, and of generating motion in other bodies; that if the air, the ocean, and the solid ground were deprived of this active

principle, they would be perfectly inert and quiescent, for the plain reason that the volume, elastic force, mobility, and chemical power of all bodies are diminished by every reduction of their temperature; consequently, that caloric does not consist in the vibratory motions of ponderable matter, as supposed by Rumford, Davy, Young, and others, nor in "the successive polarization of its particles;" but that it is the *cause* of vibration, without which there could be no sound, light, life, nor motion in the universe. It is, therefore, chimerical to call in question the materiality of the only agent in nature that is omnipresent, as it is to speculate about its cause or origin, unless we confine our inquiries to the mode in which it unites with, and separates from ponderable matter, or to the mechanical, chemical, and vital effects it produces.

Sir Charles Morgan observes, that "the manifest connexion of living energy with temperature, and with developement of the respiratory function, leads to an idea that heat is the specific bond of connexion;" but that "the ignorance in which we are placed in regard to the nature and origin of fire, fixes an obvious bar to the knowledge of the affections of organized beings by that cause;" and that "the influence of respiration on life has yet to be sought;" that "in attempting to extend the limits of inquiry, the map must be traced after the discoveries of a

Columbus, not covered with an imaginary Terra Australis, or fancied Atalantis," &c. (Philosophy of Life, p. 148, 156, 384.) Dr. Southwood Smith also observes, that "whether the blood acquires something from the atmosphere which is essential to life, or part with something incompatible with life, is wholly unknown." (Philosophy of Health, vol. ii. p. 436.)

Among those physiologists who regard respiration as the source of animal temperature, it is still undecided what proportion of the oxygen consumed is converted into carbonic acid; whether the combination of oxygen with carbon takes place in the air cells of the lungs, as maintained by Black, Crawford, Lavoisier, Ellis, and Dalton; or in the general course of the circulation, as supposed by Lagrange, Hassenfratz, Edwards, and some others. With the exception of Priestley, the early experimenters concluded that nearly all the oxygen absorbed during respiration, was expired in the form of carbonic acid. But it was soon after discovered by Crawford and Lavoisier that about 25 per cent. of the oxygen consumed disappeared; from which they concluded that it united with hydrogen to form water. Similar results were obtained by Sir H. Davy, from numerous experiments on himself; for he found that the oxygen absorbed was in the proportion of 100 to 81.66 of what was exhaled from the lungs.

There is reason to believe that if physiologists

had attended to the nature of the animals experimented on, their results would have been less contradictory; and that the various tribes of carnivorous animals generate much less carbonic acid, in proportion to the amount of oxygen consumed, than herbivora. For example, it was found by Allen and Pepys, that pigeons absorbed 16 per cent. more oxygen than they expired in the form of carbonic acid, and guinea pigs 20 per cent. In the experiments of Berthollet, the difference was 25 and 30 per cent. in the rabbit and Guinea pig; while in those of Despretz, it was from 25 to 34 per cent. in the same species of animals. But in the cat, dog, and hawk, Dulong found the difference from 20 to 50 per cent; owing, as he justly inferred, to the difference between the chemical constitution of vegetable and animal food. (Journal de Physiologie, 1823.)

Dr. Edwards also states, from his own experiments, that in guinea pigs and yellow hammers, the difference was in the ratio of 100 to 82.26; while in puppies it was as 100 to 53. He further ascertained, that green frogs and lizards consume much more oxygen than is returned in the form of carbonic acid, (which Spallanzani had found to be the case in many of the lower species of animals.) (Influence of Phys. Agents on Life, p. 216, 218.) And Müller informs us, that in fishes, Treviranus found the difference to vary from 50 to 75 per cent.

What then becomes of the surplus oxygen? Does it unite with hydrogen, as supposed by Crawford, Lavoisier, Cuvier, Dulong, and Despretz; or with the blood, as maintained by Edwards, and many other physiologists? Müller thinks it may combine with the blood, giving it a bright arterial hue, but not with hydrogen, because Collard de Martigny found that aqueous vapour was exhaled from the lungs of animals when deprived of oxygen. But this objection is not well founded; for if 25 per cent. of the oxygen consumed by a healthy man in 24 hours, (which is about 45,000 cubic inches, or 2 lbs. in round numbers,) were to unite with hydrogen, it would make only 9 oz. of water; whereas it is known that from 18 to 20 oz. are exhaled from the lungs in that time. Nor does the fact stated by Magendie, that the exhalation is increased by injecting warm water into the veins, affect the question, which must be decided by ascertaining the relative proportions of hydrogen in arterial and venous blood.

If ever we shall be enabled to reduce the phenomena of life to the certainty of fixed principles, it must be accomplished by ascertaining the elementary composition of organized bodies, and the changes they undergo at every stage of their developement; what is added to our food, during its conversion into chyme, chyle, and blood; what changes are effected on the atmos-

phere by respiration; what the blood receives and what it loses, while passing through the lungs, and during its circulation through the systemic capillaries; above all, what enables it to excite the heart, and maintain the activity of all the vital functions. This should be the ultimate aim of our researches. For if all diseases are owing to some deviation from the natural state of organized bodies, it is clearly impossible to comprehend the right method of their treatment, without knowing the conditions of healthy action.

Let us then agree with Aristotle, that, "if there be any description of knowledge more high and excellent than another, it is that of the animating principle." But if the cause of animal life be obtained from the atmosphere by breathing, as taught by Moses, and sanctioned by the universal common sense of mankind, it must be a *bonâ fide* constituent of the atmosphere, therefore a portion of nature, and not a hyperphysical essence, as supposed by some modern theorists; who have confounded the physical cause of animal motion with sensation, volition, and thought, which are operations of the nervous system, and not material entities; for they cannot be added to, and subtracted from bodies, like caloric, electricity, and other forms of matter.

It also follows, that if the atmosphere be composed of oxygen, nitrogen, aqueous vapour, and carbonic acid, united with some still more refined

species of matter, one of these must be the primary cause of vital action. And as it is now well known that oxygen is the only gas capable of supporting life by respiration, the question arises whether it produces the effect by its immediate agency, or by the evolution of an imponderable fluid, as during the process of combustion. But if the number, diversity, and specific character of plants throughout the earth be determined by the amount of caloric derived from the sun, it follows *à fortiori* that the vital force of animals, and the developement of their organization must be regulated by the quantity of the same agent, which I have shown to be the active principle in light, electricity, oxygen, and all the other forms of matter. Yet no regular and systematic attempt has ever been made to connect the theory of animal temperature with the laws of life, or the phenomena of sanguification, secretion, nutrition, sensation, volition, and muscular motion.

If it can be shown that there is more carbon in the venous than arterial blood of all animals, it must be given off while passing through the lungs, because it is found to be diminished immediately afterwards. And if the proportion of carbon be greater in the venous blood of herbivora than of carnivora, it will explain why the former generate more carbonic acid in proportion to the amount of oxygen consumed by respiration. For the same reason, if the ratio of *hydrogen* be

greater in the venous than arterial blood of carnivorous than of herbivorous animals, it must also be given off in the air cells of the lungs, whether it unites with oxygen to form water or not. And if there be more nitrogen in the arterial than venous blood of animals, it must be derived from the atmosphere by respiration. But so far has this department of Organic Chemistry been neglected, that no one has ever attempted to ascertain the relative proportions of oxygen, carbon, hydrogen, and nitrogen, in the venous and arterial blood of different animals, with the view of discovering the true theory of respiration. The consequence of thus rejecting a whole series of facts has been, that nearly everything most important to be known, remains still involved in deep obscurity, or vitiated by fallacious hypotheses.

That there is more hydrogen in the chyle of carnivorous than of herbivorous animals, would appear from the researches of Dr. Marcet, who found that when taken from the thoracic duct of dogs nourished for several days on animal food alone, it presented a milky appearance, and afforded an oily, opaque substance, that rose to the surface like cream. When separated and kept for some time, it assumed the consistence of soft butter; it also decomposed much sooner, and afforded a larger proportion of ammonia than chyle taken from the horse, which was transparent and

colourless, but contained more carbon than the chyle of dogs. (Medico-Chirur. Trans. vol. vi.)

And that the venous blood of all animals contains more combustible matter than that of the arteries, would appear from the following results of Michaelis, which were obtained by analyzing the colouring matter, fibrin, and albumin, separately, of blood taken from the calf. (Schweigger's Journal, vol. liv.) "Nor can there be a doubt, that when a sufficient number of similar experiments shall have been performed on the blood of different animals, they will be found to correspond with the results of Dr. Marcet."

	Colouring matter in		*Fibrin in*	
	Venous blood.	*Arterial blood.*	*Venous.*	*Arterial.*
Carbon	53.231	51.382	50.440	51.374
Nitrogen	17.392	17.253	17.207	17.587
Hydrogen	7.711	8.354	8.228	7.254
Oxygen	21.666	23.011	24.065	23.787

	Albumin in Venous blood.	*Albumin in Arterial blood.*
Carbon	52.650	53.009
Nitrogen	15.505	15.552
Hydrogen	7.352	6.993
Oxygen	24.484	24.436

Now if we take the average of the whole, it will be found that the proportions are as follows:

	Venous blood.	*Arterial blood.*
Carbon	156.321	155.765
Nitrogen	50.104	50.402
Hydrogen	23.298	22.601
Oxygen	70.215	71.234

So far as these analyses are to be relied on, (and they are perhaps the most correct of any yet published,) they show that the proportions of carbon and hydrogen are greater in venous than arterial blood; viz. immediately before, than after passing through the lungs; consequently, that they must be there given off. They also show that the ratios of oxygen and nitrogen are greater in arterial than venous blood. That a portion of nitrogen is absorbed from the atmosphere and united chemically with the blood, might reasonably be inferred from the fact, that there is very little of it in the food of herbivorous animals, in whose blood it is no less abundant than in that of carnivora.

Accordingly, it has been ascertained by the experiments of Sir H. Davy, Pfaff, Henderson, and others, that variable proportions of nitrogen disappear during the respiration of man and other animals; while Edwards contends, that it is both absorbed and exhaled at the same time, (but without stating whether herbivorous animals consume more of it than carnivora,) which Berzelius regards as incredible. More varied and accurate experiments on different species of animals are required to furnish data on which to found a sure induction. So vague are the views of physiologists, in regard to the importance of attending to the elementary composition of the blood in different animals, that in

giving the analyses of Michaelis, Macaire, and Marcet, they have generally omitted to state from what animals the blood was obtained.

Now if it be true, that carnivorous animals consume from 20 to 50 per cent. more oxygen by respiration than is returned in the form of carbonic acid, as shown by the experiments of Dulong, Despretz, Edwards, and Treviranus, (the latter makes the difference still greater in fishes,) what, I repeat, becomes of the surplus oxygen? Does it unite with the hydrogen exhaled from the lungs; or with the blood, as supposed by Edwards and others? That it combines with hydrogen to form water, and contributes largely to the evolution of animal heat, would appear from the fact, that the temperature of carnivorous animals is not inferior to that of herbivora, although the former generate much less carbonic acid; whereas it has never been proved that the combination of oxygen with the blood is attended with an elevation of temperature, unless carbonic acid be formed. Edwards maintains that carbonic acid is formed in the general course of the circulation, because he found it to be exhaled in notable quantities from the lungs of frogs and young kittens, when confined in vessels of pure hydrogen, and from fishes placed in water deprived of oxygen. Müller also states, as the result of his own, and the experiments of Bergman, that frogs exhale

from $\frac{3}{10}$ to $\frac{96}{100}$ cubic inch of carbonic acid in from 6 to 12 hours, in gases that contain no oxygen; or nearly as much as they generate in atmospheric air. (Elements of Physiology, p. 339.)

But it is impossible to reconcile these results with the experiments of Mr. Ellis, who found that carbon (not carbonic acid,) was exhaled from the stigmata of bees and other insects, after all the oxygen of the air in which they were confined was consumed. (Inquiries, Sections 133, 137, and 671.) The formation of carbonic acid in the blood is also disproved by the fact, that variable proportions of carbon and hydrogen are given off by venous blood while passing through the lungs, as shown by their diminished quantity in arterial blood, according to the analyses of Michaelis.

That different gases may exist in a state of mechanical mixture with the blood, and be separated from it by means of the air pump, has been shown by the experiments of Magnus, who found the proportions of carbonic acid, oxygen, and nitrogen, in the arterial and venous blood of the horse and calf, as follows; making from 10 to $12\frac{1}{2}$ per cent. of gaseous matter by volume.

	Horse.		*Calf.*	
	Arterial.	*Venous.*	*Arterial.*	*Venous.*
Carbonic acid	17.7	18.8	16.4	16.3
Oxygen	6.3	4.8	6.5	2.8
Nitrogen	2.5	2.8	4.2	1.9

These experiments show that there is more oxygen and nitrogen in arterial than venous blood, and a little more carbonic acid in the latter. But if they prove anything in regard to the theory of respiration, it is, that carbonic acid is not formed in the general circulation. For if generated in the arterial blood, it ought to contain more carbon than venous blood, which is not the case; and if in venous blood, its temperature ought to be higher than that of the arteries; for the obvious reason, that caloric is always evolved during the formation of carbonic acid. But the most decisive proof that the latter is generated in the lungs, and not in the general circulation, is, that *the temperature of arterial is higher than that of venous blood*, as long ago observed by Haller, Black, Plenck, and Menzies.

This important fact, which was denied by Cullen, and overlooked by nearly all other physiologists, has been completely established by the experiments of Dr. John Davy, Magendie, and Holland. In an excellent paper, recorded in the Philosophical Transactions for 1814, it was shown by Davy, that in lambs, sheep, and oxen, the blood is from 1 to 1.5^{0} warmer in the carotid arteries and left ventricle of the heart than in the jugular veins and right ventricle.

In another series of observations made in 1838, and recently published among other physiological researches, he has shown, that in sheep,

the difference is in some cases 3°; which I have verified by repeated experiments. He also found that the blood of a spaniel bitch was 104° in the right side of the heart, but 107° in the left ventricle and pleura; thus demonstrating that the lungs have a higher temperature than other parts of the body, which Cullen had ironically said ought to be the case if animal heat were the effect of respiration. And as Haycraft, Delarive, and Marcet had shown that equal volumes of the different gases have the same capacity for heat, Davy proved that it is nearly the same in arterial and venous blood; thus sweeping away all the crude speculations founded on the erroneous experiments of Crawford, who represented the capacity of oxygen gas as 4.7, compared with carbonic acid, which he made 1.6; that of arterial blood as 1.03, and venous blood as ·89. Yet Dr. Davy maintains that animal heat is owing to the fixation or condensation of oxygen in the blood, and to the combinations into which it enters in the circulation. (Physiological and Anat. Researches, vol. ii. p. 171.)

Müller observes, that the formation of carbonic acid in the capillary vessels of the body explains why the lungs are not warmer than any other part of the system. (Elements, p. 333.) But we have seen from the excellent observations of Davy, that the pleura, which surrounds the lungs, and the blood that comes immediately

from them, are actually warmer than other parts of the body. And as the fact has been called in question by other physiologists, I have several times repeated his experiments, during the last and present winter, on sheep and oxen; the result of which has been, that in every trial, the temperature of the lungs and left side of the heart, were from 2^0 to 3^0 higher than that of the stomach, liver, and brain, or the blood of the *vena cava* and jugular veins.

Müller adds, that the object of respiration is evidently the absorption of oxygen into the blood, which conveys that gas as a stimulus to the different organs of the body; and secondly, the removal from the blood of the carbonic acid which is formed in the capillaries (p. 341). But that oxygen does not excite the heart to contract, the stomach to digest, the nerves to feel, the brain to think, and the various organs to perform their respective functions, would appear from the experiments of Bichat, who found that when injected into the jugular veins of a dog, death speedily ensued; and it is known that farriers are in the habit of killing horses no longer fit for service, by injecting air into the veins. Nysten also found that when oxygen was introduced into the venous blood of animals, no carbonic acid was evolved, although it acquired the scarlet hue of arterial blood. And that atmospheric oxygen is not essential to the

existence of those imperfect organizations termed entozoa, which are formed in the brain, liver, muscles, eyes, and other parts of the higher animals, is evident from the fact, that it has no access to them, which is also true in regard to the primordial germs of all animals.*

That a small proportion of oxygen is absorbed by the blood, and contributes to its formation, is highly probable; but I have proved that by far the greater part of it unites immediately with carbon and hydrogen in the lungs. If then it be true, that caloric is always disengaged during the formation of carbonic acid and water, and that the lungs are the source

* A decisive proof that the blood of animals is not vitalized by oxidation and decarbonization, is, that during the respiration of plants, carbonic acid is absorbed by the leaves and decomposed, its carbon being retained, and its oxygen returned to the atmosphere, the purity of which is thus maintained. Dr. Gilly found that when grass leaves were exposed to the sun in a jar four hours, the following changes were produced :

At the beginning of the experiment, there were in the jar :—		At the close of the experiment, there were in the jar :—	
of Nitrogen	10·507	of Nitrogen	10·507
Carbonic acid	5·700	Carbonic acid	·37
Oxygen	2·793	Oxygen	7·790
	19·000		18·667

But that the circulation of sap, and its conversion into the nutritive fluid of plants, is effected by the agency of solar heat, is evident from the fact, that neither light, electricity, air, water, nor any other physical agent, will produce the phenomena at a low temperature.

of animal temperature, the latter cannot be "owing to the fixation or condensation of oxygen in the blood, and the combinations into which it enters in the circulation," as maintained by Dr. Davy; nor to "the combination of oxygen with carbon in the systemic capillaries," as supposed by many modern physiologists.

Should it still be urged, that the agitation of venous blood with oxygen gives it the arterial colour, I answer that sugar, nitrate of potass, sulphate of soda, chloride of sodium, carbonate of potass, sal ammoniac, and even carburetted hydrogen (according to Berzelius), produce the same effect, but destroy its vitality, and power of coagulating. Moreover, when arterial blood is withdrawn from the system, it acquires the colour and other properties of venous blood, without either the loss or gain of ponderable matter. For it was found by Hunter, that on tying the carotid artery of a dog in two places, the blood between the ligatures soon acquired the dark venous hue; and by Hassenfratz, that when confined in glass tubes, hermetically sealed, it underwent the same change of colour as when placed *in vacuo*, hydrogen, nitrogen, carbonic acid, or common air. Müller admits, that as arterial is converted into venous blood while passing through the systemic capillaries, the former ought to contain principally oxygen, and the latter carbonic acid in solution. But we have seen, from the experiments of Magnus which he

reports, that arterial contains nearly the same proportion of carbonic acid as venous blood, but the former a little more oxygen and nitrogen. The truth is, that if carbonic acid were formed in the systemic capillaries, (as maintained by Edwards, Müller, Dr. Prout, and others,) they ought to have a higher temperature than the lungs, for the obvious reason, that whenever oxygen unites with carbon caloric is evolved, whether during ordinary combustion, fermentation, or respiration. But that the temperature of arterial blood is reduced, instead of being augmented in the systemic capillaries, is evident from the fact, that on returning to the right side of the heart, it is found to have lost from 1° to 3° of caloric, together with its bright florid hue, and power of maintaining the actions of life, just as the steam of an engine loses its elastic force and the power of moving the piston, after undergoing a reduction of temperature.

That venous is converted into arterial blood during its passage through the lungs, was long ago proved by the experiments of Lower, Mayo, Hewson, Hunter, Goodwin, and Bichat, who, in various species of animals, observed it to pass from the right side of the heart, through the pulmonary artery, of a dark hue, and return by the pulmonary veins to the left ventricle, of a bright florid complexion. It must not, however, be supposed that the vital properties of the blood are essentially connected with its colour, which

is absent in insects, nearly all the lower orders of invertebrated animals, and is confined to a small proportion of the blood in fishes; from which it would appear, that colour is rather a concomitant, than an essential or vital property of the blood.

In regard to the agency of caloric in producing a change of colour, some interesting experiments were performed by Crawford, who found that after immersing a dog, with the exception of his head, in water at 45° F. for fifteen minutes, his venous blood was the darkest he had ever observed; but on placing another dog in water at 114° for thirty minutes, it was of a scarlet hue, and could scarcely be distinguished from that of a neighbouring artery.* (Experiments and Observations on Animal Heat, pp. 310, 387.) And Dr. John Davy states, that there is much less difference between the colour of arterial and venous blood of sheep when the temperature is 80° or 90°, than during winter in England, or when the mercury is below 32°. (Physiological and Anatomical Researches, vol. ii. p. 140.) In accordance with these facts, it may be observed,

* He supposed that the dark colour of venous blood was owing to the carbon it obtained during its circulation through the systemic capillaries; and that by elevating the temperature of an animal above the natural standard, this change was prevented from taking place. But the experiments of Hunter, Hassenfratz, and others, demonstrate that arterial blood passes into the venous state without either the loss of oxygen or the gain of carbon.

that after immersion for some time in a cold bath, the surface of the body assumes a purple hue, as when exposed to a very cold atmosphere; but if transferred to a warm bath, the skin changes to a bright scarlet colour. It is, therefore, obvious that the arterial blood of the cutaneous capillaries is venalized by the abstraction of caloric alone, without any loss of ponderable matter, and again arterialized without the addition of oxygen. Again, if it were established that venous blood is brightened by uniting with oxygen, and darkened by parting with carbonic acid, the injection of oxygen into the veins will not support life when the chemical function of the lungs is arrested, any more than nitrogen, hydrogen, or any other description of ponderable matter. As a further proof that oxygen is not the agent by which the fluids are formed, and converted into the various tissues by vital affinity, it has no access to the germ of the fœtus, which is nourished and lives before any communication is established with the blood of the mother by means of the placenta.

From all the foregoing facts we are authorized to conclude, 1. that during the passage of dark venous blood through the lungs, it gives off variable proportions of carbon and hydrogen, that unite chemically with atmospheric oxygen to form carbonic acid and water, as in ordinary combustion, by which it acquires an addition of caloric, with a bright florid hue; and 2. that

during its circulation through the systemic capillaries, the caloric obtained from the atmosphere is transferred to the solids, by which their temperature and vitality are maintained, when the blood returns to the right side of the heart of a dark modena hue, having lost its power of stimulating the organs, until it acquires an additional quantity of caloric from the lungs.

Dr. Prout observes, in his late Bridgewater Treatise, that "the phenomena of life are wholly removed from the logic of quantity." But if respiration be the source of animal life, the phenomena are resolvable into additions and subtractions of measurable elements; and it is only because they have not been ascertained with numerical accuracy, that physiology has never yet been reduced to the character of an exact science. For if it be true that the conversion of food into chyme and chyle is effected by its union with gastric juice, bile, and pancreatic liquor; that chyle is transformed into more highly organized particles of blood, by giving off water, carbon, and hydrogen, while passing through the lungs, in exchange for which it receives caloric from the atmosphere, with variable proportions of nitrogen, there is no good reason why the proportions of each should not be reduced to "the logic of quantity."

According to some recent experiments of Dr. Ure, caloric enough is evolved during the combustion of 1 lb. of charcoal to melt 75 lbs. of ice,

which would raise 150 lbs. of water 70°. Now if we suppose that 45,000 cubic inches of oxygen are consumed by a healthy man in 24 hours, making about 2 lbs. in round numbers; and that 40,000 cubic inches, or a little more than 1 lb. 12 oz. are expired in the form of carbonic acid, it must unite with about 12 oz. of carbon;* so that if the same proportion of caloric be given out as in ordinary combustion, it ought to compensate the loss of $52\frac{1}{2}°$ in a man weighing 150 lbs. And if the remaining 5000 cubic inches of oxygen combine with $\frac{1}{8}$th its weight of hydrogen, (we have seen that the proportion of oxygen which disappears is generally much larger in carnivorous animals,) it ought to raise the temperature of 150 lbs. of water 12°; allowing, with Dr. Thomson, that caloric enough is evolved during the combustion of 1 lb. of hydrogen to melt 400 lbs. of ice.

Lavoisier and Laplace inferred, from their experiments, that during the combustion of 1 lb. of charcoal, caloric enough was evolved to melt 96 lbs. of ice; and that nearly the same amount was given off by animals in proportion to the

* Dr. Dalton calculated that the aliment which he took in 24 hours contained about $11\frac{1}{2}$ oz. of carbon; but that the mean quantity exhaled from the lungs did not exceed $10\frac{1}{4}$ oz.; the remainder passing off with the other excretions. He thinks that of the 6 lbs. of food and drink taken daily by a healthy man, 1 lb. consists of carbon and nitrogen, the remainder being chiefly water. (Manchester Memoirs, Vol. II. N. Series; and Ed. New Phil. Journal, 1832, 1833.)

quantity of oxygen consumed by respiration. But on repeating their experiments, by surrounding animals with water, and comparing the elevation of its temperature with the amount of oxygen consumed, Dulong and Despretz inferred that from 9 to 25 per cent. more caloric was imparted to the water than could be accounted for by the absorption of oxygen, (in accordance with the theory of Lavoisier and Laplace,) allowing it to combine with carbon and hydrogen; and that in no case did respiration afford more than $\frac{9}{10}$ths of the heat given off by the animal. M. Despretz, therefore, concludes that respiration is the principal source of animal temperature, but that *a small remaining portion (petite portion* restante) *is generated by motion of the blood, friction, assimilation*, &c. (Ann. de Chim. et de Phys. t. 26.)

But it is scarcely possible to believe, that animals could remain from one hour and a half to two hours surrounded with water, without losing more caloric than they gain from the atmosphere by breathing, or that they should not undergo a reduction of temperature; and if it were established that they give out $\frac{1}{10}$th more caloric, in proportion to the amount of oxygen consumed, than is evolved during the union of the same quantity of oxygen with carbon and hydrogen out of the body, I should still maintain that the process of combustion, by which animal life is supported, is perfect; whereas that of the

chemist is always more or less imperfect, and attended with loss from radiation, not to mention other sources of error.

My own opinion is, that instead of invalidating, the experiments of Dulong and Despretz are strongly in favour of the chemical theory proposed by Black, and supported by the most distinguished physiologists of modern times. In regard to the hypothesis of M. Despretz, that "the small remaining portion" of caloric not accounted for by respiration, is generated by motion of the blood, friction, assimilation, &c. I answer, that whenever the process of respiration is arrested, the motion of the blood, friction, assimilation, &c. are no longer carried on, and that the temperature of the whole system falls rapidly to that of the surrounding medium.

In reply to the arguments of Brodie, Philip, Tiedmann, Edwards, and others, who contend that animal heat is generated by nervous influence, secretion, nutrition, the condition of the blood, and muscular contraction, I shall proceed to prove that the mean healthy temperature of all animals is directly in proportion to the amount of their respiration; without which there could be no sanguification, secretion, nutrition, nervous influence, nor muscular contraction, and that they have mistaken effects for the cause of animal heat.

CHAPTER III.

Influence of Respiration on the Temperature and Vital Energy of Animals.

"If errors had not been rooted in men's first notions, some things justly discovered might have rectified others; but as errors have been fundamental, and of such a kind that men have rather neglected and passed things over, than formed a wrong or false judgment about them, it is no wonder if they never attained what they never had in view; not arrived at the end they never proposed; nor performed the course which they never entered."

BACON.

If ever the theory of Medicine be destined to take its appropriate rank among the exact sciences, it must be founded on precise and enlarged views of the cause which governs all the movements of nature, including those of the animal economy. And there is abundant reason to hope, that when the attention of mankind shall be once thoroughly aroused to the importance of throwing off the paralyzing trammels of authority, they will very soon be able to dispel the numerous obscurities that have hitherto retarded the progress of discovery. For it is certain that if the cause of sanguification, digestion, secretion, nutrition, sensation, and muscular motion be derived from the air by breathing, *it must be a positive agent, subject to*

the logic of quantity, whatever men may say about its mysterious and hyperphysical properties.

All erroneous theories in physiology and pathology, have arisen from partial examinations of nature as one harmonious and indivisible system, all the operations of which are governed by one principle, in accordance with the most simple and perfectly uniform laws—from the stupendous revolutions of the heavenly bodies, to the circulations of "the invisible air," and the refined transformations of universal chemistry.

Having already shown that the power of the earth to multiply organic forms is regulated by the amount of caloric it receives from the solar fountain, I proceed to prove that *the organizing power of animals, and the activity of their respective functions, are directly in proportion to the quantity of the same active principle derived from the atmosphere by respiration.*

Among all the operations of nature, there is nothing more calculated to excite admiration, than the silent, beautiful process of living combustion, by which the temperature of the more perfect animals is maintained at nearly a uniform standard in all climates, during winter and summer. Yet so little has the importance of the subject been appreciated, that physiologists are as much divided in their opinions in regard to the immediate source and agency of animal heat as in the age of Harvey, Sydenham, and Mayo.

It has been known since the time of Linnæus and Dr. Black, that all the higher orders of animals are warm-blooded; that they have a double heart and a double circulation, by one of which their blood is distributed throughout the lungs, where it is exposed to the atmosphere; and by the other, sent throughout the system,—that the breathing apparatus of birds is larger, in proportion to the size of their bodies, than in any other description of animals, extending through all the cavities of the abdomen, and even of the bones; that they consume more oxygen, generate more carbonic acid, and have a higher mean temperature.

Next to birds, mammiferous animals have the largest organs of respiration. And although confined to the thorax, they consist of innumerable cells that present a vast extent of surface to the atmosphere. The consequence of which is, that many of them are capable of maintaining their temperature in the coldest parts of the world. Accordingly, it will be seen by glancing over the following Tables, that the mean temperature of birds varies from 105° to nearly 113° F. which is about 28° above that of the tropical regions; while in mammalia it varies from 96° to 106° in their active and healthy state. But if we descend to the lower orders of air-breathing vertebrated animals, such as Chelonians, Saurians, Ophidians, and Batrachians, in which the heart

is so constructed that only a portion of blood is sent through their imperfectly developed lungs, we find that the power of obtaining caloric from the air by respiration is small; that their temperature rises and falls with that of the surrounding medium, and rarely exceeds it more than a few degrees in their most active condition; while in fishes, crustacea, mollusca, annelida, and all the more imperfect animals that live in water, and breathe by means of branchiæ or gills, it is still less, as may be seen by referring to the third Table.

It was discovered by Lavoisier, more than fifty years ago, that two sparrows confined in a vessel of air generated more carbonic acid in a given time than a young guinea pig under the same circumstances. And it has been recently estimated by Treviranus, from the experiments of different physiologists, that for every 100 grains weight of birds, they generate in 100 minutes nearly twice as much carbonic acid as mammalia, and the latter above eight times more than the frog, as may be observed in the ensuing Table. (Müller's Elements, p. 312.)

	Oxygen consumed. Cubic inch English.	Carbonic acid exhaled. Cubic inch.	
Pigeon	1·14	0·96	Allen and Pepys.
Ditto.	1·58	0·99	Despretz.
Guinea Pig	0·67	0·42	Berthollet.
Ditto.	0·74	0·60	Allen and Pepys.
Ditto.	0·68	0·47	Despretz.
Rabbit	0·60	0·44	Berthollet.
Cat	0·98	0.66	Despretz.
Frog	0·00	0·06	Müller and Treviranus.

TEMPERATURE OF BIRDS.

Names of the animals.	Temperature of the animals.	Observers.
Bearded Vulture	112·89° F.	Pallas.
Snow Bunting	110·24	Pallas.
Grouse	108·	Pallas.
Snipe (Lesser Godwit)	108·	Pallas.
Oyster Catcher	106·	Pallas.
Bullfinch	108·	Pallas.
Ruff	108·	Pallas.
Redpole	111·70	Pallas.
Female	110·24	Pallas.
Swallow	111·70	Pallas.
Hawk	109·72	Pallas.
Pigeon	106° to 112·75	Holland.
The same	109·37	Despretz.
Sparrow	Feb. 105°. Apr. 108° to 111· July.	Edwards.
A young Drake	111·	Dr. J. Davy.
A young Duck	110·	Dr. J. Davy.
Adult Turkey Cock	109·	Dr. J. Davy.
Turkey Hen	108·	Dr. J. Davy.
Fowl, full grown	108·50	Dr. J. Davy.
two months old	111·	Dr. J. Davy.
Goose	107 to 111·	Dr. J. Davy.
Guinea Hen	110·	Dr. J. Davy.
Common Thrush	109·	Dr. J. Davy.
Jackdaw	107·75	Dr. J. Davy.
Screech Owl	106·	Dr. J. Davy.
Common Crow	108·15	Despretz.
Yellow-hammer	109·18	Despretz.
Mean of the whole	109·53.*	

* Nearly all the above results were obtained by introducing the thermometer into the rectum, during life, or into the blood or entrails soon after death. It is also worthy of notice, that the temperature of vigorous young birds is somewhat higher than that of adults, as in the duck, and common fowl; and higher in the male than female, as in the turkey, duck, and redpole. The experiments of Dr. Edwards on the sparrow, in connexion with those of Dr. J. Davy on the human subject, would further lead to the conclusion, that the temperature of all the smaller species of animals is higher during summer than winter.

TEMPERATURE OF MAMMALIA.

Names of animals.	Temperature of the animals.	Observers.
Man	96° to 102° F.†	Davy.
Monkey (Sim. Aygulia.)	101 to 104·50	Davy.
Sheep	103 to 106	Davy.
Spaniel Bitch	105	Davy.
Cur Dog	102·50 to 103·50	Davy.
Bull Dog	102	Davy.
Jackall	101	Davy.
Common Cat	101 to 102	Davy.
The same	103·60	Despretz.
Leopard	102	Davy.
Goat	103 to 104	Davy.
Elk	103	Davy.
Guinea Pig	102	Davy.
Common Hog	103	Davy.
The same	104	Braun.
Calf	104	Braun.
Hare	104	Pallas.
Rabbit	103·5 to 106·50	Holland.
Arctic Fox	106·75	Fisher.
The same. (— 32°)	106	Fisher.
Female (the air, 26°)	104·75	Fisher.
Wolf (the air, 27)	105	Fisher.
Ermine	104·45	Pallas.
Squirrel	102	Davy.
Common Rat	102	Davy.
Weasel	103	Davy.
Horse	99·50 ‡	Davy.
Indian Elephant	99·50	Davy.
Ox	100 to 101	Davy.
The Whale	102	Scoresby.
Porpoise	100	Scoresby.
Polar Bear	100	Capt. Lyon.
Tiger (Ceylon)	98	Davy.

† From the observations of Dr. John Davy on 114 individuals of the human species, of both sexes and of all ages, in various parts of the world between England and the tropical portions of the East Indies, the temperature in the mouth varied from 96·5° to 102°, and was generally found to be 1° or 2° higher when and where the atmosphere was at 80°, than in England during the colder seasons of the year.

‡ I have found the temperature of the horse 102° while standing in the stable, and 105° after an hour's exercise in the open air.

TEMPERATURE OF COLD-BLOODED ANIMALS.

Names of the animals.	Temp. of the medium.	Temperature of the animals.	Observers.
Large tropical Turtle....	79·50° F.	84·00°..	Davy.
The same	80	88·50 ..	Davy.
Common Frog	61	70	Davy.
Tortoise	....	....	
Active Lizard	74·75 ..	82·61 ..	Czermack.
Green Lizard	61·25 ..	68·50..	Czermack.
Spotted Lizard..........	54	59	Czermack.
Camelion	72	74	Murray.
Coluber	83	90	Davy.
A brown Snake	82·50 ..	84·50 ..	Davy.
Adders	58	68	Hunter.
Boa	73	75	Wilford.
Natrix Lævis	69	80	Czermack.
Proteus Anguinus	59·55 ..	68·73 ..	Czermack.
Geometrical Tortoise......	61	86·90 ..	Davy.
Another	79	91	Davy.
Shark .... in water	74·75 ..	77	Davy.
Bonito (Tunny)	80·50 ..	82	Davy.
Common Trout..........	56	58	Davy.
Flying Fish	75·50 ..	78	Davy.
Crab..................	51·80 ..	59	Rudolphi.
Black Snails............	54	57	Rudolphi.
Earth Worms .. in a phial	56	58·89..	J. Hunter.
Leeches ...... in a phial	54	56·80..	J. Hunter.
Bees in the hive .. in May......		102	Réaumur. (Nat. Hist. des Insects.)
The same .... in Jan.	6°	55	Réaumur. (Nat. Hist. des Insects.)
Swarming season		104	Huber. (Mem. sur les Abeilles.
In winter	30	86	Huber. (Mem. sur les Abeilles.
An Ant hill	55·40 ..	68	

After the foregoing sheets were printed, being obliged to retire into the country for a few months, in consequence of ill health, brought on by over exertion of the nervous system, from too intense application to the subject of this work,—I embraced the opportunity of making some additional observations on the temperature of such domestic animals as came in my way. Most of them were made in the month of August, by placing the bulb of a medical thermometer under the fore arm, which was gently pressed against the thorax. They were performed with a view of ascertaining the influence of season and of age in modifying temperature. From which it will be seen, that in some of the more active mammalia, it was higher than the average represented in the second table. The observations on fowls, ducks, and a few other birds, corresponded with those of Davy and Edwards, therefore have been omitted as unnecessary.

TABLE IV.

Temperature of a young she goat, 3 months old	107°
Mother of the same, old, and in poor condition	104
A tame young rabbit, 2 months old	108
A fine active kitten, 2 months old	105·5
A vigorous cat, nearly full grown	104
Mother of the kitten, 3 years old............	103·5
A very old cat, said to be in its 19th year	102
An active cur dog, 3 months old	106
A fine active young horse, 4 years old........	104
A mare, 20 years of age, (in vaginam).... ...	100

Thus it would appear, that in the same species

of animals, the temperature is higher during youth than middle age, still lower in old age, and higher during summer than at any other season. We have seen that Dr. J. Davy found it higher in the human species under the tongue, within the tropical than the temperate latitudes. And I have ascertained by about one hundred observations on myself, during the last eighteen months, that a nicely graduated thermometer placed under the tongue, varies from 97° to 100° during winter, and from 100° to 102° or 103° occasionally, during summer; while in April and May, the average has been about 100°. I have also found it from 1° to 2° higher on first awaking in the morning, and throughout the day, than at 12 o'clock at night, when it has always been at the minimum, except after taking supper, or returning from a brisk walk, both of which augment the quantity of respiration.

But what is the specific office of caloric in the operations of life? Within the last few years I have often propounded this question to various members of the medical profession, without receiving any better answer, than that *it is to keep us warm.* With a view of ascertaining what the uneducated portion of the community think about it, the question was put to a common barber; *What is the use of animal heat?* To which he replied without hesitation, "*to make us live and grow?*" Surprized at the novelty of this answer, his reasons

were demanded, when he again replied with equal readiness, "*Without the heat of the sun there could be no life and growth of vegetation.*" Such is the difference between the unsophisticated common sense of mankind, founded on the daily observation of what is continually passing around us in nature, and the mystic jargon of books filled with metaphysical speculations about "the unknown vital principle"—which have tended only to divert the votaries of science from the path that leads to the acquisition of positive and useful knowledge.

> " Some truth there is, but dash'd and brew'd with lies,
> To please the fools, and puzzle all the wise."
>
> DRYDEN.

Corresponding with the facts exhibited in the foregoing tables, the whole organization of birds is more highly developed, and their different functions are performed with greater rapidity, than in mammalia. The stomach is more concentrated, digestion more vigorous, the heart larger in proportion to their weight, its walls thicker, and its pulsations more frequent. Their blood is more highly organized, or richer in fibrine and red particles, their secretions more copious, and the renewal of their composition by nutrition more rapid. Their bones are harder, their muscles more firm, and their vital power of contraction greater, as shown by the activity of all their movements, and the immense velocity

with which many of them glide through the pathless air to distant regions, in opposition to the force of gravity. For it is well known, that the hawk and eagle are capable of flying forty-five miles per hour, the carrier pigeon from fifty to sixty, and a species of swallow termed the swift, at the rate of ninety miles per hour,—which, if continued for twelve hours, would make 1080 miles a day. And such is the enormous strength of the ostrich, combined with rapidity of movement, that if we are to credit the account of Adanson, as reported by Mason Good, it has been known to out-run the swiftest race-horse, with a burden equal to its own weight upon its back. (Book of Nature, vol. i. 325.)

So great is the power of digestion in birds, that common fowls require $2\frac{1}{2}$ ounces of solid barley per day, as proved by the experiments of Moubray; or about $\frac{1}{20}$ of their whole weight, supposing the latter to average three pounds. But there is reason to believe, that the smaller and more active species of birds consume a much larger proportion of oxygen than fowls, geese, turkeys, ducks, and other large birds, especially such as are confined to the surface of the earth. For if it be true, as stated by Lavoisier, that two sparrows generate and expire more carbonic acid in a given time than a young guinea pig, they must consume three times the ratio of oxygen; as the average weight of sparrows is about one ounce,

and that of a young guinea pig about six ounces, while it is worthy of notice, that they are both granivorous animals. In accordance with these data, which can be regarded only as approximations to the truth, Moubray says, that the domestic pigeon requires 1 oz. 2 drs. of solid barley per day; so that if we estimate the average weight of pigeons at 12 oz. they must digest about $\frac{1}{10}$ of their whole weight every twenty-four hours. It therefore follows that the composition of fowls is renewed in a period not much exceeding twenty days, and that of pigeons in a much shorter time, as might be inferred from the rapidity of their growth, which is remarkable in all the feathered tribes.

The brain and nervous system are also more highly developed in small, than in the larger species of birds; especially in the canary, bullfinch, and several of the songsters, including the parrot tribe, and more so in some of them, than in any other description of animals, not even excepting man.* Hence the remarkable acuteness of

* On the authority of Haller and Cuvier, Mr. Lawrence gives the weight of the brain in several species of birds, compared with that of the whole body, as follows:

Canary	1..14	Blackbird	1..68
Sparrow	1..25	Falcon	1..102
Chaffinch	1..27	Duck	1..257
Fringilla	1..27	Eagle	1..260
Red-breast	1..32	Goose	1..360

Nor is it unworthy of notice, that in the ostrich, cassowary, swan, condor, and turkey, the relative size of the brain is still less, corresponding with their well known stupidity.

their senses, their sagacity in foreseeing changes of weather, in the construction of their nests, and in providing for their wants. Hence also their delightful genius for music, the social and almost human affections of some, including the faculty of articulating words, together with all those beautiful instincts which many have regarded as a species of inspiration. But although in a very few of them the brain is larger in proportion to the size of the body than in man, its convolutions are less numerous, and its frontal portions less developed, coinciding with the activity, yet limited range of their intelligence. Nor is it unworthy of passing notice, that the pigeon, sparrow, and some other among the smaller species of the feathered races, rear from six to eight broods of young every season in the middle latitudes, all of which attain their growth in a few weeks; while it is known that the common fowl often affords one hundred eggs annually, if well nourished and protected from the inclemency of the weather, or even one hundred and fifty in a few cases, according to Buffon.

Again; those mammalia in which the organs of respiration are most fully developed, possess the highest degrees of vital energy. For example, the chest of the dog, wolf, fox, goat, deer, horse, ox, sheep, hare, rabbit, and some other species of quadrupeds, is larger, in proportion to the size of the body, than that of man, and their temperature

several degrees higher, as we have already seen. The consequence of which is, that they are capable of resisting much greater degrees of cold, and of enduring muscular exertion for a much longer time, without exhaustion.* The thorax of the greyhound is larger in proportion to his size, than that of any other quadruped; and it is well known that, for a short distance, he will surpass the swiftest race-horse,—that, with a fair field, he will overtake the hare, fox, deer, and rabbit, in a few minutes, during which his speed is equal to that of the wild pigeon, which flies at the rate of a mile every minute for several hours.

The thorax of the common foxhound is larger, in proportion to his weight, than that of the

* When I come to treat on the influence of climate and season, food and drink, exercise, repose, &c. it will be shown that the lungs of man and other mammalia, from the greater necessity of exercising them, are more developed in the higher latitudes than in the tropical regions,—that they are larger in the dog, wolf, fox, polar bear, reindeer, and other animals which inhabit cold climates, in proportion to the size of the body, than in the elephant, rhinosceros, camel, tiger, leopard, or even the lion,—whose temperature, muscular activity, and power of enduring cold, are proportionally less. It will also be seen that respiration, the power of enduring intense cold, and protracted muscular exertion, are greatly diminished by starvation, and that vital heat is expended by over-exertion faster than acquired. As an example of this, it has been said that 30,000 horses belonging to the French army perished in one week, chiefly from cold, during the fatal retreat from Moscow, when the mercury was only 20° below the freezing point of water; whereas it is certain that, when well fed, and not over-exerted, this noble animal is capable of enduring a temperature of 40° or 50° lower, without house or clothing.

ordinary horse, and he will pursue the chase for a longer time without exhaustion—sometimes for above three hours, and to the distance of forty or fifty miles. As a further proof that the vital energy of the hound exceeds that of the horse, the former requires $1\frac{1}{2}$ lbs. of actual nourishment per day, such as hard biscuit and fat, making $\frac{1}{40}$ of his whole weight, which is about 60 lbs. But the usual allowance of a common work horse is equivalent to twelve quarts of oats per day; so that if a bushel of oats average 37 lbs.* two-thirds of which, or $24\frac{1}{2}$ lbs. consists of pure meal, he must consume above 9 lbs. of solid food, independent of chaff; and about $\frac{1}{70}$ of his whole weight, if the latter be estimated at 700 lbs. From which it follows, that the composition of the hound is renewed in about forty days, and that of the horse in about seventy days.

The capacity of the chest and nostrils of the fine blooded race-horse is also larger, in proportion to the size of his body, than in any other description of the horse kind; corresponding with his great muscular strength and activity. These

* A bushel of oats weighs from 32 to 42 lbs. (average 37 lbs.) and affords 74·3 per cent. of actual nourishment, according to the analysis of Sir H. Davy. The cavalry allowance in England is four feeds, consisting of eight quarts of oats every twenty-four hours, and 12 lbs. of good meadow hay, which contains about 8 per cent of nutritive matter,—making in all nearly 8 lbs. of nourishment. In Spain and Portugal, horses in the army are allowed 8 lbs. of barley per day.

conditions are owing to the expansion of his lungs, and the developement of the muscular system by active exercise, by which he is disencumbered of all useless fat; so that the greater part of his blood and vital energy are expended on the organs of locomotion.* Besides, we are informed by Darvill, that, while in training, he requires fifteen quarts of oats daily, which must afford about 12 lbs. of actual nourishment. It is, therefore, obvious, that a larger amount of carbon and hydrogen is given off in the lungs of the race-horse than in those of the ordinary horse,

* For the same reason, the goat, sheep, deer, ox, hog, ass, and many other animals, are more active in the wild state than when domesticated, over-nourished, and prevented from taking much exercise. The wild buffalo, or bison, is no less remarkable for the size of his chest than for strength and swiftness in running, compared with the tame and unwieldy ox. The wild ass, also, is scarcely surpassed in fleetness by the finest horse, although slow in his general movements when made a mere beast of burden. But even then his muscular strength is superior to that of man; for I have observed that a small donkey, supposed to weigh about 170 lbs. is capable of carrying to market, without any apparent difficulty, a burden of 250 lbs. including the rider, a distance of four miles,—which is certainly more than the stoutest London porter could perform. We are, therefore, authorized to conclude, that all animals whose power of obtaining caloric from the atmosphere by respiration exceeds that of man, surpass him in the powers of digestion, secretion, nutrition, and muscular motion. The reproductive power of the rabbit, hare, cat, dog, hog, and other animals of hot temperament, is also greater than in man,—greater in nearly all the different species of birds and mammalia, especially those of small size, during summer than winter, when they are less playful and sprightly.

ceteris paribus,—that he obtains more caloric from the atmosphere by respiration; that his blood is richer and more abundant; and that his composition is renewed more rapidly, or in about sixty days.

Again; that the aggregate vital energy of the horse is greater, in proportion to his size, than that of man, would appear from the following facts:—First, that his tractive power has been found equal to that of six men, whose collective weight is about six times 150 lbs. making in all 900 lbs.; whereas that of the horse has been estimated at an average of only 700 lbs. Secondly, that a man in full health, weighing 150 lbs. digests about $1\frac{1}{2}$ lbs. of actual nourishment daily, which is only about $\frac{1}{100}$ of his whole weight, and much less than what we have seen to be the ratio consumed by the horse. From which it follows, that, in a state of the most vigorous health, man requires above three months for the renewal of his organization, allowing that all his actual nourishment is converted into blood and his several tissues.* Coinciding with the above

* It is here worthy of notice, that, before chyle is converted into blood, it must give off more or less carbon and hydrogen in the lungs; so that the quantity of blood generated must be proportionally less than that of the food consumed. The difference, however, is small, and cannot materially affect the foregoing calculations, which may be regarded as a sufficiently near approximation to the truth, as will be shown when I come to the influence of food on respiration.

facts, it is well known to medical men, that a broken bone of a young and healthy individual, when rightly set, acquires its former strength in from forty to seventy days, more or less, according to the age and constitution of the patient.*

The thorax is larger in men than in women, its mean circumference being about thirty-six inches in the former, and thirty-two in the latter. It is therefore not surprising that the blood of men is more highly organized, their muscles more fully developed, their brains from four to eight ounces larger, (as shown by Tiedemann,) with a corresponding superiority of muscular and intellectual power. Nor was there ever an individual of great vital energy, whether of the brain, stomach, or muscles, without large and sound lungs, which are essential to the sanguine and heroic temperament. The muscular and intellectual powers of small men with large and sound lungs, are greater than in large men with narrow chests, who naturally belong to the phlegmatic temperament. They are also greater in lean than in fat men, *ceteris paribus*, because in the former, the *blood and vital energy* of the system are ex-

* But so rapid is the nutritive or formative process in birds, that, when a bone is broken, it requires only about three or four weeks to unite and become strong, if kept in apposition. The *vis medicatrix naturæ* is, therefore, only another name for the aggregate vital energy of animals, and is in proportion to the quantity of caloric they derive from the atmosphere by respiration.

pended chiefly on the brain and organs of locomotion; whereas in the latter, a portion of the blood is converted into fat, that becomes a burden to its owner, and in every way detracts from the energies of body and mind. Hence the observation of Shakspeare, that *fat ribs make lean pates.*

And if we descend to the lower orders of air-breathing animals, whose mean healthy temperature is from 30° to 50° below that of birds* and mammalia, and falls to that of the surrounding medium during winter in the higher latitudes,

* That birds consume at least twenty times more oxygen in proportion to their weight than reptiles, would appear from some experiments performed by Dr. Edwards, who found that a frog was capable of living above three days when confined in a vessel containing sixty-four cubic inches of common air; (with a solution of pure potass for absorbing the carbonic acid exhaled,) whereas, under the same circumstances, a yellow-hammer of the same weight lived only one hour. Nor can there be a doubt that many of the smaller birds devour more food in one day, than reptiles of the same size in twenty. For it is well known, that frogs, toads, salamanders, tortoises, and many other reptiles, are capable of living several weeks without food, or suffering any material diminution of weight, and that serpents are often many weeks in digesting a single meal. Spallanzani relates an instance of one that was three months in completing the digestion of a fowl. He also found that in snakes, the process was more rapid in June, when the temperature was 82° than in April when at 60°. Hence the slow growth of all cold blooded animals, compared with birds and mammalia. Nor can there be a doubt, that the muscular power of the latter is from ten to twenty times greater than that of reptiles, *ceteris paribus*,—for example, that in a horse weighing 700lbs. it is ten times greater than in a tropical turtle of the same weight, and twenty times greater in a sparrow than a frog.

we shall find that their powers of digestion, circulation, sanguification, secretion, nutrition, and muscular motion, are exceedingly low,—that the lungs, heart, stomach, brain, muscles, and other organs, are imperfectly developed, compared with the whale, dolphin, porpoise, and other cetacea, which have large lungs, abundance of rich arterial blood, and, like all warm blooded animals, a highly organized stomach, heart, brain, and muscular system. The truth is, that scarcely any part of reptiles is more than half formed; while some of their organs may be said to exist in a merely rudimentary state. Corresponding with the obtuseness of their senses, and the low grade of their intelligence, it has been observed by naturalists, that the brain of a crocodile twelve feet long, and of a serpent eighteen feet long, does not exceed from 1 to 2 drams in weight.

If we descend the scale of organization from reptiles to fishes, crustacea, mollusca, and other animals which breathe with gills instead of lungs, and live constantly in water, which contains only about 1 per cent. of free oxygen by volume, we find, that although formed of the same elements, animated by the same principle, and constructed after the same model, as the highest species, they resemble abortions compared with the finished beauty of form exhibited in birds and mammalia. For example, the heart of fishes is exceedingly small, its walls thin, its pulsations slow and lan-

guid, the arteries small and few, the blood pale and watery, the muscles flaccid, the bones soft, or replaced by cartilage, while the brain consists of a few small knots or ganglions, with a corresponding defect of the senses.* And notwithstanding they move with great velocity through water, it is owing to the density of that medium, by which they are enabled to propel themselves onward by a small exertion of vital force; nearly all of which that they possess is expended on the muscles employed in locomotion. But as Cuvier observes, they are soon exhausted by exertion, which is true of all cold blooded animals.

As a further proof that the aggregate vital energy of all animals is directly in proportion to the developement of their breathing apparatus, it may be added, that by means of stigmata or holes, arranged along their bodies, and minute vesicles for conveying air throughout the system, the active insects are more fully supplied with organs of respiration than any other description of animals, not excepting birds. As an example of the large amount of oxygen they consume, Spallanzani found that a caterpillar generated more carbonic acid in a given time than a frog, and

* The eyes are without lustre, the organs of hearing scarcely distinguishable, and so imperfect are those of voice, that they have no power of uttering sounds, but vegetate in perpetual dumb silence, without even the animal desire of sexual communion, or the slightest regard for their offspring.

butterflies still more. Corresponding also with the facts exhibited in Table III. p. 566, we learn from the experiments of Mr. Newport, recorded in the Phil. Transactions for 1836—7, that wasps, hornets, beetles, moths, and some other insects, have a much higher temperature than that of the surrounding air, and that it is always in proportion to the quantity of oxygen they consume by respiration, which is always augmented by exertion, and diminished by repose.

In accordance with the above facts, and with all the analogies of nature, the whole organization of the higher insects is very complex and refined. For, although like all avertebrated animals, they have no brain in the head, nor central sensorium, they are supplied with a series of knots or ganglions, extending along the interior of their bodies, and connected with each other by nervous cords; while it is known that some of them are covered over with organs of vision. Hence the extreme acuteness of their senses, and the wonderful sagacity displayed in the economy of bees, ants, and many other species of insects. The honey-bee has, to a certain extent, the same emotions of fear, anger, revenge, and affection as man. It also remembers, compares, and reasons; for, while disporting in the joyous sunshine, and culling sweets from the flowery fields, it looks forward to a change of season,

avoids the approach of rain, wind, and other injurious conditions of the weather; while, in the construction of its honey cells, it exhibits the perfection of mathematical skill.

But we are told that all this is mere *instinct*, because it is not improved by education. What then shall we say in regard to the wonderful improvement of fleas, which has recently been displayed under the guidance of an experienced teacher in the Strand? Do they not afford proof that the *march of intellect* is not confined to man? and if we admit that bees construct their cells with as much art the first day of their commencing to labour, as after three years of experience, and that they do it by *instinct*, must not the latter depend on the peculiar organization of their nervous system? and if within the limited range of their appointed labours, they operate with more consummate skill, without education and experience, than man, it is because they are employed on only a few objects, to which they are adapted by their organization, and directed by a species of physical necessity, arising from their wants; just as birds of passage are directed by their sensations to seek warmer climates on the approach of winter,—or for the same reason that the eye of the eagle can discover small objects at a great distance, and that the sense of smell is more acute in the common hound, than in any other description of animals,

viz. because the optic and olfactory nerves are larger, and expanded over a greater extent of surface.

As an example of the complex mechanism of the higher insects, we are informed that Lyonet discovered 4061 distinct muscles in the *Cossus*, (while in the caterpillar state) an insect which resembles the butterfly. And as an example of the prodigious muscular power of the more perfect insects, Richerand states, that the common grasshopper has been known to leap two hundred times its own length; while there is reason to believe, that in proportion to his size, the flea is still more active and strong.

In all attempts to improve the science of physiology, it should be our leading object to discover the primary physical cause of animal motion; and whether it resides in the blood as maintained by Moses, Hippocrates, and all the ancients; or in the nervous system, as supposed by the great majority of modern authors. Until these fundamental questions are decided, the theory of life, health, and disease, must continue involved in profound darkness. Nor is it less certain, that the whole theory of nature must remain a sealed book, so long as attraction, repulsion, chemical affinity, polarity, irritability, and sensibility, are regarded as ultimate phenomena, or confounded with primary causation. It is therefore high time that we should look beyond

the surface of things to the mainspring of all power, whether in living or dead matter.

In accordance with the universal belief of antiquity, it was maintained by the illustrious Harvey, that what the Romans termed *calor vitalis*, is *the primary and immediate cause of the heart's action, and of vitality in the blood, which he describes as the common bond of union among all parts of the living body.* "In quo, vegetativæ et sensitivæ operationes primo elucent, cui calor, primarium et immediatum animæ instrumentum, innascitur, qui corporis animæque commune vinculum est, —et quo vehiculo anima omnibus totius corporis partibus influit." (Op. Omnia, p. 388.) He further maintained that the animating principle is a finite portion of the universal spirit that actuates all nature,—termed by the Greeks Ψυχη τȣ Κοσμȣ, and by the Romans *Anima Mundi*,—which phrases signify *soul of the world.*

But this simple and rational doctrine was destined to be superseded by the speculations of Willis, Baglivi, Hoffman, Gaubius, and Barthez, who confounded the animating principle with some unknown hypothetical fluid, supposed to be generated in the brain, from which it was conveyed to all parts of the body by nerves. According to Stahl, the organizing principle which he termed the *Anima*, is endowed with intelligence, and corresponds with the Φυσις of Hippocrates, with this exception, that he regarded it as an immaterial essence.

It was also maintained by the celebrated Boerhaave, that all the operations of the living body are governed by the agency of an universal catholic fluid, the most subtile and elastic principle in nature, termed by the Greeks and Romans *anima mundi.* But he supposed that the action of the heart, stomach, and other involuntary organs, is owing partly to the influence of arterial blood, and partly to the agency of a *nervous fluid*, generated in the cerebellum; while the voluntary muscles derive their power from the influence of a nervous fluid secreted in the cerebrum, as first suggested by Willis. And so confused were his notions in regard to the source of animal heat, that with Bacon, Boyle, Borelli, and other mechanical physiologists, he represents it as an *effect of the heart's action, friction, and motion of the blood, because when the circulation is vigorous, the body is warm, but cold when it is languid.** (Institutions in Physic. pp. 16—61—116.)

Although it must be confessed, that this logic is not precisely after the manner of Euclid, it is not a bad specimen of what may be found in the works of our most distinguished modern philoso-

* He further maintained, that every variety of fever and inflammation is owing to a deranged condition of the blood, and its too slow, or too rapid movements, as during the cold and hot stages—that all spasmodic affections are owing to a vigorous influx of nervous influence into the muscles, and paralysis, to a stoppage of that influx. Op. Cit. pp. 216—250.

phers, who have equally confounded cause and effect. Sir Isaac Newton himself has fallen into a like error, when he says that "*animal motion may be performed by vibrations of the æther, excited in the brain by the power of the will.*" For how can the brain will, unless previously vitalized? or if the will depend on the activity of the brain, how can it be the cause of its *supposed* vibrations, or of any other species of cerebral motion? Is it not manifest, that sensation, memory, and volition, are mere modes of action of the living principle, exerted through the nervous system? For when life ceases, they are wholly extinguished; therefore, like the mind itself, cannot be regarded as material entities (as they have neither extension, solidity, nor any other properties of tangible matter,) but as effects of the same cause that generates attraction, repulsion, vibration, chemical affinity, and all the motions of passive matter.

But it was reserved for the celebrated Cullen to erect on the ruins of nearly all that was true in the medical doctrines of antiquity, one of the most visionary systems ever invented by the subtilizing genius of man; and which has exerted an astonishing influence in retarding the progress of sound practical knowledge. Although he admits that all the phenomena of health and disease must be referred to the moving powers of the animal economy, he maintains that digestion,

circulation, secretion, nutrition, sensation, and muscular motion, including the generation of animal heat, are owing to the agency of a *subtile and elastic principle,* inherent in the medullary substance of the brain; and which he termed the nervous fluid, or the nervous power,—that this fluid or power is the prime mover in the animal body, and determines the activity of all the organs, whether voluntary or involuntary,—that as it appears only in the living, and disappears entirely in the dead state of the body, it must be regarded as the vital principle,*—and that it regulates not only the various degrees of muscular strength, but the quantity, quality, and distribution of the fluids, with every variety of temperament. (Materia Medica, p. 55, 88, 99.)

In accordance with this hypothesis, he taught that all medicinal and morbific agents exert their influence primarily on the nervous system, and not through the medium of the blood, as maintained from the days of Hippocrates down to the

* But if caloric, in some of its forms, be the cause of all elasticity, it must be the very same principle which Cullen terms the nervous fluid, and describes as the prime mover in the animal economy. Moreover, although he maintained that cold, miasmata, and all other causes of disease, produce their effects by operating immediately upon the nervous system, and not through the medium of the blood, he does not fail in his faithful and generally accurate descriptions of disease, to inform us, that in all the varieties of malignant fever, small-pox, scurvy, dysentery, and tetanus, the blood exhibits a disorganized state, and coagulates very imperfectly or not at all.

time of Harvey. And it is remarkable that he should have rejected the humoral pathology, on the ground of our ignorance in regard to the office of blood in health, and of the changes it undergoes in disease.

The supposition that nervous influence is indispensable to muscular contraction, was long ago disproved by the experiments of Haller and Fontana, who found, that when the chest of an animal was laid open, and the nerves going to the heart were stimulated, its contractions were neither accelerated, nor renewed when at rest. And Dr. Philip has since demonstrated, that even the voluntary muscles retain their irritability as long after their nerves have been divided, as when left entire,—that chemical stimulants which excite them to contract when applied immediately to their fibres, produce no effect when applied to their nerves alone.* Yet the majority of

* He says, that "the power of the muscular fibre is a property depending on the mechanism of that fibre, and in no degree directly depending on the nervous power." Yet he maintains that "animal heat must be ranked among the secretions:" that it is evolved from the blood like the various secretions, by nervous influence, because the temperature of animals is reduced by injuries of the brain, spinal marrow, and division of the vagus or eighth pair of nerves, and their secretions diminished; as if the cause of muscular contraction were different from that of secretion. In another place he observes, "we have reason to believe that nervous influence is the galvanic fluid, collected by the brain and spinal marrow, and sent along the nerves." But he says again, that "neither nervous influence nor galvanism can excite

modern physiologists who have not adopted the views of Cullen, maintain with Haller, that all the phenomena of life may be referred to two fundamental properties, *irritability* and *sensibility*, the one inherent in the muscular fibre, and the other, in the medullary tissue. But as these properties cannot exist in any part of the body before they are formed, it is self evident that they are secondary effects of the organizing principle; while it is equally manifest, that the *vital attraction*, the *vital affinity*, and the *vital contractility* of Dr. Alison, are modifications of one and the same power by which the blood is formed, united with the different organs, and the whole maintained in a state of activity.

The theory proposed by Bichat was only a modification of that adopted by Cullen; for he referred the contractile power of the heart and all the involuntary organs to the ganglionic system of nerves, which he regarded as the

the actions of animal life, except in parts endowed with the vital principle, whether the latter be something superadded to bodies, or only a peculiar arrangement of their parts." (Experimental Enquiry, pp. 156—219—248—265—267, &c.)

It is painful to trace the flounderings and contradictions of so great an experimenter as Dr. Philip, who has overlooked the admirable precept of Newton, that no more causes of natural things ought to be admitted, than such as are true and sufficient to explain the phenomena. For if neither galvanic electricity, nor nervous influence, can excite the actions of life in parts not endowed with the vital principle, why admit them as causes of secretion and the evolution of animal heat?

source of organic or unconscious life,—(corresponding with that of plants, the *vital* and *natural functions* of the ancients, and those termed *vegetative* by Harvey,) while he supposed that the brain, spinal marrow, and their nerves, were the organs of sensation, perception, and the power of regulating the movements of the voluntary muscles. The objections to this theory are, 1. That contractility is a property of all living matter, including every description of plants, and even the medullary tissue; for the brain undergoes contraction and expansion during violent emotions, or active thinking. 2. That all the operations of life, whether voluntary or involuntary, are *organic*. 3. That among all the lower orders of animals which have neither brain nor spinal marrow, but only ganglionic nerves, and some of them only a single cord extending along the body, as in the earth-worm,—there is not a single species destitute of sensibility, consciousness, and volition; for the lowest worm seeks nourishment, and recoils from the approach of harm: while the more active insects are endowed with far higher degrees of intelligence than many animals which have a brain and spinal marrow,—with emotions of love, anger, fear, and perhaps, to a certain extent, the sentiments of justice and benevolence.

Thus it is, that without resorting to the cruel experiments of vivisection, (which always deranges the natural state of the functions, and has

led to so many erroneous conclusions,) we learn by a simple appeal to comparative physiology, that the office of the ganglionic nerves is identical with that of the brain, spinal marrow, and their nerves. For as Cuvier truly observes, by comparing the structure and functions of different species, in which "nature adds to, or subtracts from, each of their different parts, just as we might wish to do in our laboratories, and shows herself the results of such additions and subtractions,"—we may easily ascertain the specific office of any one organ. The truth is, that the brain may be regarded as a large ganglion, or concentration of nervous matter, of which the spinal marrow is a mere continuation; and the nerves of both, as expanded branches, with which the ganglions in the higher animals are connected; and the object of which is to endow the involuntary organs with so much sensibility as may be requisite to their well being. But as the heart, stomach, and all secretory organs, are excited to action by the stimulus of blood, there is no necessity for their being subject to the commands of the *sensorium commune*, like the locomotive muscles, or even the sphincters of the bladder and rectum. Let us then reject the doctrine of Müller, that "the ganglia are the centres of organic life," and that "the cerebro spinal system alone is capable of exciting voluntary motion." (Elements of Physiology, pp. 734—934.)

The celebrated Cuvier seems at one time to have aimed at more enlarged views of the animal economy; for he observes that the vital energy of animals, and the developement of their organization, are in proportion to the amount of their respiration. But like his illustrious predecessor John Hunter, he was so completely fettered by the prevailing doctrine of the schools, that in his introduction to the *Regne Animal*, he says that "as the heart, stomach, and other involuntary organs, are affected by the nervous system, it is probably the source of their contractile power." And again; "as all the animal fluids are derived from the blood by secretion, there cannot be a doubt, that the *nervous fluid* is secreted by the medullary matter, from which it is conveyed to all parts of the body by the nerves."

The fundamental error of regarding the brain or any part of the nervous system, as the source of vital energy, will appear evident from the following undeniable facts:—1. That life exists throughout the vegetable world, and in many species of the lower animals termed zoophytes, polypi, entozoa, &c.—in none of which has the slightest trace of nervous matter ever been discovered;—consequently, that all those physiologists who have regarded nervous influence as the source of vital energy, have vainly endeavoured to explain a universal by a partial fact:—2. That the germs of all the higher animals are developed

and endowed with vitality, before any part of the nervous system,—consequently, that the latter must be a secondary effect or product of the organizing principle :—3. That the aggregate vital energy of animals is directly in proportion to the quantity of their respiration, or of caloric that passes through their tissues, and bears no uniform relation to the developement of the brain and nerves :—4. That the nervous system, like all the other organs, is formed from and vitalized by the blood, which is formed in the lungs, by the same active principle that causes the seeds of plants to germinate, and the germs of animals to unfold from a simple albuminous mass, into highly organized bodies.

Yet we are told by Tiedemann, "that the developement of the locomotive organs is in proportion to that of the nervous system." (Compar. Physiology, p. 182.) And Mr. Mayo says, that "the nervous system determines the rate at which each function proceeds, the quantity of secretion, and the frequency of involuntary motion." (Outlines of Physiology, p. 264.) Again; Magendie observes, that "we are totally ignorant in regard to the cause of muscular motion, but must seek for the impulse which sets our various tissues in motion, in the nervous system." (Lectures on the Nerv. System.) Dr. Edwards also maintains, that "the predominance of the nervous system in warm blooded animals, renders all parts of the body

more excitable, giving the greatest energy to the nutritive functions." And Sir Charles Bell observes in his late work on the nervous system, that "vital power is possessed through the agency of nervous matter, diffused through all animals, from the simplest up to man." (1836, p. 17). Dr. Billing also maintains, that "the nervous system regulates and supplies all the organs with energy, and that without nerves there is no organic contractility." (Principles of Medicine.) And Müller contends, that "the organs of animals manifest as great a dependence on nerves, as plants do on light." (Op. Citat. p. 43.) In the same strain, we are told by Mr. Earle, that "the agent which causes animal heat, the fluidity of the blood, and maintains all the functions of life, is something which proceeds from the brain, along the spinal marrow to the extremities of the nerves; and that animal heat is as much to be considered a secretion as bile, saliva, or gastric juice." (New Expos. of the Nerv. System, p. 137.)

As if to fill up the measure of our astonishment, Edward Johnson observes, that the heart and all the other organs derive their power of action from a fluid brought to them by the nerves from the brain, by whose action that fluid is produced, —that wherever there is an artery, vein, or absorbent, there must also be a nerve to enable these vessels to convey their fluids, &c. But, as if conscious that all this amounts to nothing in the

way of explanation, he says again, " If you ask me for the cause of the first life, I answer your question by another:—What is the cause of gravitation, chemical affinity, &c. but the *Causa Causarum?* the *Deity himself?*" (Life, Health, and Disease, pp. 66—72.)

But why should I quote further examples of a doctrine which is taught by nearly all modern physiologists, and by some of them carried even further than was ever contemplated by Cullen? Having already shown that nervous influence is not the cause, but a secondary effect of vital energy, it may be right to show, by a brief reference to comparative physiology, that the muscular strength and locomotive power of animals are not in any proportion to the developement of the nervous system. As a striking example of this, the brain of man is perhaps fifty times larger than that of the ostrich, which is no less remarkable for stupidity, than for its prodigious muscular power; for if we are to credit the accounts of travellers in Africa, it has been known to surpass the fleetest race-horse, with a full-grown negro on its back. She does not, however, seem to be ignorant of the fact, that her eggs may be hatched by the agency of solar heat, independent of nervous influence, when buried in the hot sands of Senegal, where she sits on them only at night.

The brain of the greyhound, like that of the fox, hare, rabbit, goat, deer, and many other

species of mammalia, is exceedingly small: but as he is made up chiefly of lungs, blood, and muscles, he is the swiftest of all runners except the ostrich. The brain of the horse and ox varies in weight from 1 lb. 4 oz. to 1 lb. 7 oz.; while that of man varies from 3 lbs. 2 oz. to 4 lbs. 6 oz. Yet the muscular power of the horse is equal to that of six men. Besides, if the brain were the source of vital energy, such men as Bacon, Shakspeare, Newton, Milton, Franklin, Napoleon, Byron, and all others that have large heads, ought to possess the energies of life in the highest degree; whereas it is certain, that, in men of genius, the powers of digestion, secretion, nutrition, and muscular motion, are generally inferior to what they are in individuals of the athletic temperament, who are often remarkable for the smallness of their heads, and a deficiency of intelligence.

According to Rudolphi, the brain of a full-grown Greenland whale, *(Balena Mysticetus,)* seventy-five feet long, weighs only 5 lbs. 10 oz. 4 drs. But as the cetacea have large lungs, and a temperature that varies from 100° to 104°, with a corresponding amount of rich red blood, the muscular power of the whale is equal to that of several hundred men. John Hunter states, that, from the capacity of the heart and aorta, from 80 to 120 lbs. of blood must be discharged by the left ventricle at each contraction. The weight of this

enormous animal has been estimated at 140,000 lbs.; and it has been said that, when of the largest size, it has afforded above 20,000 lbs. of oil. We have no accurate information in regard to the weight of the brain in the sperm whale, which measures eighty-four feet in length, and is larger than the *Balena Mysticetus.* But Mr. Beale states, that the cranial cavity of one fifty-eight feet six inches long, measured fourteen inches in width, ten inches in length, and nine inches in depth—that the spinal canal, which is of a triangular form, measured ten inches in width at the base, where connected with the brain, and eight inches in depth; but only seven inches wide, and six and a half deep at the seventh dorsal vertebra, from which it diminished to the termination.*

Should it be urged that the brain of the ele-

* The most remarkable fact connected with the natural history of the cetacea is, the length of time they are capable of remaining under water. Mr. Beale says, that the male sperm whale continues below the surface from one hour to seventy, and even eighty minutes, when he rises and breathes for ten minutes; but that the female remains only twenty minutes below and four minutes above the surface. (Beale on the Sperm Whale, p. 45.) The means by which they are enabled to effect this, exhibit a striking adaptation to the medium in which they exist, and doubtless depend on the vast amount of blood contained in the numerous convolutions of vessels found in the thoracic and abdominal cavities, as first noticed by Hunter,—all of which is vitalized during the short time they remain above water, by a rapid process of breathing, and thus prepared to maintain the activity of their functions from twenty to sixty and even eighty minutes, while in search of food in the depths of the ocean.

phant weighs from 8 to 10 lbs. I answer, that his muscular power is far inferior to that of the horse, ox, dog, wolf, deer, and other mammalia, in proportion to their size. So that, notwithstanding the absolute size of the brain is larger in the whale and elephant than in man, it is very much smaller, compared with the magnitude of the body, and its superior frontal portions less perfectly developed. The consequence of which is, that, in the range of their intellectual faculties, they are as far inferior to man as they are his superiors in muscular power. And although the brain of the canary, sparrow, and chaffinch, be larger, in proportion to the size of the body, than in any other animated beings with which we are acquainted, its convolutions are much less numerous than in man, and the intellectual portions less fully developed, compared with the inferior and posterior compartments. But the muscular power of these birds is not greater, in proportion to their weight, than that of the pigeon, whose brain, compared with the whole body, is in the ratio of 1 to 90; while in man, the average ratio is as 1 to 40, (excepting idiots, in which it is often not much larger than in infants, according to the measurements of Tiedemann,) but varies with the different degrees of obesity, and diminishes with old age. We are, therefore, authorized to conclude, that *the intelligence of animals is directly in proportion to the developement of their nervous system, ceteris*

*paribus; but that their powers of digestion, circulation, secretion, nutrition, absorption, muscular motion, and cerebration, depend on the amount of caloric they derive from the atmosphere by respiration.**

The specific office of the brain, spinal marrow, and their nerves, including those of the ganglionic system, is to endow animals with sensation, per-

* So far is it from being true that the brain is the source of vital energy to the other organs, that when snakes, eels, and other cold blooded animals are decapitated, the trunk remains alive much longer than the head. And Whytt states, that Redi extracted the brain from a tortoise, which afterwards lived from November until the following May, but lost the power of vision and hearing. (Essay on An. Motion, p. 386.)

It is also evident, from the experiments of Flourens, that in the highest orders of animals, the cerebrum is not essential to respiration, which is governed chiefly by the eighth pair of nerves, that arise from the medulla oblongata. For he found that, when the cerebrum of a chicken was removed, it remained in a healthy state for ten months, and even grew fat on being daily crammed with food,—that, when thrown into the air, it exerted its wings, as if endeavouring to fly, but lost the power of vision, hearing, tasting, smelling, the feeling of hunger, sexual desire, memory, comparison, and, to a great extent, all its sentient faculties. Yet we are informed by Magendie, that after the cerebrum, cerebellum, and all parts of the brain above the medulla oblongata, were removed from a hedgehog, the animal retained, in a low degree, the sense of feeling, smelling, and consciousness,—uttered cries when its whiskers were plucked, and made repeated efforts with its fore-feet to get rid of the annoyance. Volkman also found, that, when a decapitated frog was irritated with a hot iron, it leaped forwards, as if conscious of pain. We further learn, from the experiments of Granger and Barron, that, after the brain was removed from a young puppy, it made efforts to suck,—thus showing an imperfect power of volition. (Med. Gazette, April 13, 1839.)

ception, memory, volition, instinct, and all the attributes of mind,—to *direct* the various movements of the body, but not to supply the moving power,—to generate ideas, but not organic products. It is very true, that the nervous system is far more highly developed in warm than in cold blooded animals; but we shall see presently, that this is owing to the greater activity of nutrition in the former. It is also very true, that when the nerves going to a voluntary muscle are irritated, contractions are produced, and that, when divided, it can no longer contract in obedience to the commands of the will. But if the locomotive organs be not supplied with arterial blood, they become cold, insensible, and paralytic, whatever the condition of the brain may be. And if the blood be not supplied continually with caloric by respiration, it cannot excite the brain to think and will, the nerves to feel, the muscles to contract, and the glands to secrete.*

* In his late History of the Inductive Sciences, Mr. Whewell observes, that " the phenomena of the nervous system bring us in a striking manner to the passage from the physical to the hyperphysical sciences;" and he adds, that " the *nervous fluid* can neither be mechanical, chemical, nor physical,—that it must cease to be a fluid before its motions can become sensation and thought." (Vol. iii. pp. 422—430.) But if the nervous fluid be neither mechanical, chemical, nor physical, it must be a nonentity, or a mere metaphysical quiddity, and should therefore be excluded from the inductive sciences. " What can we reason but from what we know?" Yet Mr. Earle has described the circulation of the nervous fluid with as much confidence as if it were a real

It is because the voluntary muscles are more abundantly supplied with nerves than the heart, stomach, liver, bowels, &c. that they are enabled to obey the mandates of the brain. But it has often been asked, what is the use of nerves in parts not subject to the will? I answer, that without nerves in the stomach, we could not be informed by the sense of hunger, when and how much nourishment to take—that without nerves, the heart, liver, bowels, and other viscera, could not warn us of approaching disease by the sensation of pain, nor direct in the employment of suitable remedies. Through the agency of nerves distributed to the lungs, we are enabled to regulate the process of breathing, and thus to obtain the principle of life from the atmosphere. To this act, the infant is first prompted by the pain-

physical agent, and not a mere phantom of the imagination. Dr. Alison also maintains, that " vitality has no connexion whatever with the notion of mind as distinguished from matter." And even Lord Brougham has so far forgot himself as to hazard the assertion, that " mind has no necessary connexion with sensation." But it might as well be said, that motion has no connexion whatever with matter, as that mind has no necessary connexion with the vitality of the nervous system, or with sensation; for it is self-evident that, in our present state of existence, there can be no perception, memory, comparison, or, νȣς, without sensation, and no sensation without life; consequently, that all the phenomena of mind are strictly physiological. And it is only when we attempt to ascertain the mode of its operation after the dissolution of the body, that we lose ourselves in the labyrinth of the hyperphysical sciences.

ful sensation of a pressing vital want, which forces the little being to utter a cry, when the lungs expand for the reception of air, and all his embryo faculties are exalted. This half unconscious feeling continues to operate throughout the remainder of existence, and when all the outward senses are steeped in oblivion; for "not even in sleep is will resigned," as proved by the fact that respiration still goes on, though somewhat diminished, while all the higher functions of the brain are suspended. Hence it is, that when the *vagus* or eighth pair of nerves is divided, the process of breathing is diminished, the temperature of the body reduced, sanguification, secretion, nutrition, &c. impaired,—or even wholly suspended by destruction of the brain and spinal marrow—simply because respiration is a voluntary process, and the *primary function of life*, on which all the others depend. Division of the nerves going to the stomach, pancreas, kidneys, and other glands, does not prevent them from secreting their respective fluids; but if cut off from the supply of living blood by dividing or tying their arteries, the powers of secretion, nutrition, sensation, and motion, are wholly suspended.

The sensorium may be compared to the commander of an army, whose office it is to direct its movements; but the moving power resides in the army and not in the general. The external senses may also be compared to the sentinels

which give information of what is going on, while the nerves operate as messengers that convey orders from the chief to the ranks, and bring back information in regard to their condition. So long as the commander fulfils his duty, the evolutions of the army are performed with order and intelligence ; but should he be slain or wounded, and his place not taken by another chief,—or should his means of communication with his subordinate officers be cut off, the operations of the army become irregular, confused, and inefficient, because no longer guided by superior intelligence. In like manner, when the sentient power of the brain has been destroyed by suffocation, strangulation, or a violent concussion, the locomotive muscles contract spasmodically, because no longer directed by the organ of thought.

So far is the brain from being the source of moving power in the animal economy, that arterial blood is more essential to its vitality than to any of the other organs ; for if the carotid and vertebral arteries be divided or tied, it dies almost immediately,—and long before the heart and other muscles cease to contract. The reason of which is, that the brain is supplied with five or six times more blood in proportion to its magnitude, than the general system—corresponding with its exalted vitality, and the important office it has to perform as the organ of mind, by which we are enabled to hold communion with the ex-

ternal world, and to enjoy whatever is beautiful or excellent in the universe. For the same reason, birds die much sooner after decapitation or the privation of oxygen, than mammalia, and the latter than cold-blooded animals. In other words, it is because arterial blood is more essential to the vitality of the brain than to any of the other organs, that it dies in a few moments when deprived of that fluid, or when the latter is no longer arterialized by respiration ;* whereas the contrac-

* For example, when the smaller birds are deprived of oxygen, or the vessels that supply the brain with blood are divided, they become insensible in 40 seconds. When insects are smeared over with varnish, so as to prevent respiration, they die almost immediately, as shown by the experiments of Treviranus; the more active mammalia in about one minute,—whereas in man, sensibility remains for about one minute and a half, after the process of breathing has been arrested by exposure to mephitic gases, strangulation from hanging or drowning, as found by the experiments of Goodwyn and Bichat. But when reptiles and fishes are deprived of oxygen, or the great vessels are divided, they often maintain a low degree of vitality for several hours, and even for several days when the energy of their functions has been diminished by external cold. We also learn from the researches of Legallois and Edwards, that puppies, kittens, and other mammalia that are born with the eyes closed, (and in which the function of respiration is so imperfect as to resemble that of cold-blooded animals,) may be resuscitated after remaining above half an hour under water. The rationale of which is, that in proportion to the vital energy of animals, is the rapidity of its expenditure in maintaining their activity, and the necessity of its renewal by respiration, which is therefore less essential to mammalia than to insects and birds, and still less essential to the imperfect vitality of cold-blooded animals.

tile power of the muscles remains for a long time, and is not wholly extinguished until the body becomes cold, as shown by the rigidity or stiffening that takes place after death.

This brings us to one of the most important laws of the animal economy, which, when fully understood, will unfold the rationale of spasmodic diseases, and lead to the true method of curing, or rather of preventing them—viz. that *the duration of life in any part of the body, when deprived of arterial blood, is inversely as the quantity of blood required to maintain its activity.* The consequence of this law is, that whenever the chemical function of the lungs is diminished, and the vital properties of the blood are impaired, the voluntary power of the brain ceases to operate some time before the moving power of the muscles, which contract without its orders, and therefore in a convulsive manner. The more suddenly the power of the brain is arrested, the more decided and energetic is the spasmodic action, which always follows decapitation, excessive and rapid hemorrhage, strangulation, the action of hydrocyanic acid, and other narcotic poisons, the inhalation of mephitic gases, and whatever prevents the arterialization of the blood. It is therefore manifest, that convulsions are owing chiefly to diminished power of the brain, (which cannot direct the locomotive organs with intelligence, unless supplied with good arterial blood,) and

not to the "influx of a nervous fluid into the muscles," as supposed by Boerhaave,—nor to "a preternatural energy of the cerebral functions," as maintained by Bichat,—nor to some peculiar condition of the ganglionic nerves, as imagined by others.

The true theory of all spasmodic diseases must be sought in a vitiated condition of the blood, or some deranged condition of the system, by which the brain and nerves are prevented from guiding and restraining the actions of the voluntary muscles,—as in the convulsions of hysteria, the contortions of chorea, the more obstinate spasms of tetanus, hydrophobia, epilepsy, and cholera,—or the cramps that often follow immersion in cold water, and the universal tremors which attend the cold stage of fever. When I come to treat of these maladies in detail, it will be seen that the immediate exciting cause of all such actions, is deficient vitality of the blood, which in all the worst forms of cholera, epilepsy, apoplexy, and even ague, presents the dark venous hue in the arteries. And although still adequate to maintain the contractile power of the muscles, it can no longer endow the brain with sensorial energy to control their movements. So greatly are the vital properties of the blood deranged in the latter stages of tetanus and hydrophobia, that when drawn from the body it refuses to coagulate, as we are informed by Cullen, Magendie, and other

accurate observers. The object of the physician should therefore be, to restore its healthy properties by pure air, artificial inflation of the lungs, the warm bath, when the circulation is languid, genial tonics, and suitable nourishment. *A still more important requisite is, to prevent that fatal condition of the blood which constitutes the leading symptom in all malignant diseases*; for when it has been once thoroughly disorganized, the springs of life are vitiated at the fountain head.

As the nervous system is more readily deranged by morbific agents, than any of the other organs, so are its functions most easily deranged in men whose nervous organization is highly developed, by whatever diminishes the quantity of respiration, or impairs the vitality of the blood. Whether it be impure air, deficient or improper nourishment, too little or too much exertion, intemperance, the depressing emotions, &c. Hence it is, that in all ages, men of genius have been subject to fits of great mental depression, or hypochondria,—a disease that belongs especially to the poetic temperament, and is perhaps common to all individuals whose vital energy is not equal to their boundless sympathy with nature, and burning intensity of desire to render their fellow beings wiser and happier. Such were Dante, Petrarch, Tasso, Luther, Melancthon, Kepler, Shakspeare, Pascal, Milton, Newton, Johnson, Cowper, Burns, Rousseau, and Byron, with many other

"kings of thought and song,"—who in the midst of adversity, affliction, and persecution, became immortal lights in the firmament of mind, that shall shine brighter and brighter, until knowledge shall become the universal inheritance of mankind, and banish innumerable evils that now exist in the world,—the greater portion of which are owing to ignorance in regard to the physical and moral laws of the universe. But alas! how many brave spirits have perished in the conflict with prejudice and blind custom!

The most important discovery of the 19th century, was the plurality of the cerebral functions by Dr. Gall and his disciples, who have demonstrated that the perceptive, reasoning, and moral faculties in man, depend on the anterior and superior portions of the brain; and the propensities or passions, as they have been called by metaphysicians, on the lateral, inferior, and posterior divisions of the sensorium. Whether the numerous subdivisions of these more general ones have been accurately ascertained, must be determined by a more extended induction from facts. When physiologists shall have traced the connexion between the nervous organization of all animals in which it exists, with the various degrees of their intelligence, passion, and instinct, the mysteries of the nervous system will be resolved, and the physiology of mind be transferred from the hyperphysical, to its appropriate rank among the exact sciences.

In regard to the double function of the nerves, it was long ago taught by Herophilus and Erasistratus, that some are designed for sensation alone, and others for the purpose of regulating the voluntary movements of the body. This theory has been recently submitted to the test of experiment by the late Sir Charles Bell, Magendie, Mayo, Müller, and other physiologists, who although they differ on some points, maintain that the nerves arising from the posterior portions of the spinal marrow, including the optic and olfactory nerves, branches of the 5th, 7th, 8th, and 9th pairs, are destined for sensation; while those arising from the anterior portions of the spinal marrow, like the 3rd, 4th, 6th, and branches of the 5th, 7th, 8th, and 9th, are regarded as voluntary or motory, and wholly destitute of sensibility.

But as yet, the discrepancy between the results of different experimenters, and even of the same individuals, leave it more than doubtful whether there be any such thing as insensible nerves. For Magendie has arrived at the conclusion from more recent experiments, that "*the roots of the sensitive and motor spinal nerves are equally sensible when they are both entire.* But if the sensitive nerves be cut, the motor immediately lose their sensibility. And if the motor nerves be cut across at the middle of their roots, the end which remains attached to the spinal cord is perfectly

insensible, but the other end (next the ganglion,) preserves an extreme sensibility." (Medico Chirurgical Review, No. 62, p. 577.) Nor is it easy to comprehend how impressions conveyed to the brain through the external senses could be transmitted to the voluntary muscles so as to direct their movements, if wholly desitute of sensibility. And although it is highly probable, that one set of nerves may perform the office of conveying information to the sensorium, and another set that of transmitting it to the locomotive organs, it is manifest that without sensation, there could be no consciousness, memory, and volition, all of which must therefore be modifications of one and the same power, differing, however, according to the various parts of the nervous system in which it is exerted.

For example, there is a striking difference between the *sensations* of feeling, hearing, seeing, smelling, and tasting. Yet they are all *excito motory*, and may be resolved into the tactual agency of material particles. The auditory nerves are excited by the tactual influence of the atmosphere in a state of vibration, exerted on the tympanum, by which an endless diversity of words of definite meaning are conveyed to the *sensorium commune*, and the voluntary organs directed how and when to move. Seeing is produced by the tactual agency of light on the optic nerve, and the visual impressions are transmitted to the lo-

comotive organs, by which they are informed of what is going on. And so of feeling, taste, or odour, all of which are specifically different sensations, that are modified in a vast variety of ways, by the particles of material bodies acting on the nerves of feeling, taste, and smell. But how is it possible that any set of nerves could transmit these different sensations, if not endowed with sensibility? And if such were proved to be the case, I should still maintain, that unless duly supplied with arterial blood, they could be neither sensitive nor motory.

In regard to the office of the spinal marrow, a new theory has been proposed by Dr. Marshal Hall, who admits with other physiologists, that the brain and its nerves are for the purpose of endowing animals with sensation, perception, judgment, memory, and volition; but maintains that *in the functions of the true spinal marrow, there is no sensation, no consciousness, nothing psychical*:—that it presides over respiration, deglutition, nutrition, reproduction, and the action of the sphincters,—that it gives tone to the muscular system, and is the seat of all convulsive diseases, —and yet that it is, in a peculiar sense, the seat of the appetites and passions.* (Memoirs on the

* But in the Lancet of November 21, 1840, he informs us, that "life results from the pressure of arterial blood within the vascular structure of the different organs; or that life, in a word, is arterial blood."

Nerv. System, p. 70,—Lancet, February, 1835, p. 686.) It would be useless to attempt a formal refutation of a theory that contradicts itself, and which is in fact unanswerable because unintelligible. For if it be true, that in the functions of the spinal marrow, there is no sensation, nor consciousness, how can it be the seat of the appetites and passions? Or if respiration and the action of the sphincters be not subject to the voluntary power of the brain; why is it that during apoplexy, coma, and typhus, or concussion of the brain, respiration is nearly suspended, and the sphincters so far relaxed that the discharges are involuntary?

Whenever the temperature of warm blooded animals is reduced 20° or 30° below the natural standard, by surrounding them with ice-cold water, the blood loses its florid hue, the surface becomes purple or livid, the action of the heart languid, the secretions are arrested, the brain refuses to perform its office, and the voluntary muscles are seized with spasms, or become paralytic, without the loss of oxygen, electricity, or any other agent, except caloric; and if kept long in this situation, the heart ceases to beat, the crimson tide of life to run, and all the powers of motion are at an end. The graceful form of the rounded limbs is exchanged for sharp or prominent angles, the cheeks become pale and shrunken, the lustre of the speaking eye is gone,

the brightness of fancy is quenched, and the "thoughts that wander through eternity," are lost in the night of death.

What then would be the effect of immersing the human body in a bath of mercury, at the temperature of 30° below 0°? One spasmodic effort would close the scene,—and there would not be a drop of *living* blood in the system. Where then would be "the vital spark of heavenly flame"—the Archeus of Paracelsus, the *animal spirits* of Descartes and others,—the *pneumatical body* of Bacon,—the *æther* of Newton,—the *anima* of Stahl,—the *nervous fluid* of Willis, Baglivi, Hoffman, and Cullen,—the *irritability* of Glisson,—the *vis insita* and *vis nervosa* of Haller, —the *materia vitæ* of John Hunter,—the *vis vitæ* of Gœrtner,—the *excitability* of Brown,—the *nisus formativus* of Blumenbach,—the *sensorial power* of Darwin,—the *organic spirit* of Pring,—the *conservative principle* of Blane,—and the *vis medicatrix naturæ* of so many authors? Would this sudden loss of motion, sensation, and intelligence, be owing to the abstraction of some unknown hyperphysical entity, or of that spiritual fire which actuates the universe?—

> Warms in the sun, refreshes in the breeze,
> Glows in the stars, and blossoms in the trees!

If then it be true, that the quantity of life throughout the earth be in proportion to the heating power of the sun, what, I repeat, is the

use of animal heat? Is it not the essential character of a *vera causa*, that its power should be proportional to the effects it produces, and that the latter should cease in its absence? Is it philosophical to assume the existence of any more causes than are sufficient to explain the phenomena? Or if an immaterial and unknown principle of life be still admitted, will it explain anything in the absence of caloric? It is impossible to blink these questions, or to resist the conclusion they naturally force upon the common sense of every unbiased mind, that caloric is not only the cause of all excitement, but directly or indirectly, of *excitability*—that it is not only the most potent and universal stimulant in nature, but the cause of *stimulability*.

Let us now proceed to trace the natural order in which the different functions depend on each other, and the manner in which all the organs are united into one harmonious system. As it is already understood that the action of the heart is owing to the same cause on which all the moving powers of the animal economy depend, I shall proceed to shew that it is derived from the lungs by respiration, to which all the other functions are subordinate, and not from an inherent property of the muscular fibre, as maintained by Haller; nor from an inherent *propulsive force*, as maintained by Tiedemann.

It was long ago ascertained by Hunter, that

after the heart of a recently killed dog had ceased to contract, its pulsations might be many times renewed by artificial inflation of the lungs, at intervals of eight and ten minutes—a fact which has been since verified by the experiments of Brodie and many others. Bichat was also fully aware that respiration is essential to the movements of the heart; but so confused were his notions, that he observes in his "Researches on Life and Death," "the heart ceases to beat when the chemical function of the lungs is arrested, *because black blood is not of a nature to keep up its action.*"

It is generally admitted by Physiologists, that blood is the proximate exciting cause of the heart's action. But that the caloric evolved in the lungs enables it to produce this effect, is evident from the fact, that when removed from the body, and even deprived of blood, its contractions may be many times renewed and suspended, by successive elevations and reductions of temperature, without the influence of oxygen, electricity, or any other known agent. As an example of this, it was observed by Bacon, that the heart of a criminal who had been executed for high treason, when thrown into the fire, contracted with such force as to leap up seven or eight times, to the height of about 18 inches at first. (Hist. of Life and Death.) It was also ascertained by John Hunter, that when three

pieces of muscle were taken from the neck of a recently killed sheep, and placed in water at different temperatures, they contracted sooner and more firmly, in proportion to the quantity of heat applied.* Nor was he ignorant that the blood itself when removed from the body, and therefore from all nervous influence, undergoes contraction, as in the process of coagulation; and

* With a view of ascertaining the correctness of his results, I took three pieces of muscle from the neck of a sheep just bled to death, each of them an inch and a half in length, and put them into separate vessels of water, at temperatures of 80, 110, and 120°—when the one in the first vessel contracted $\frac{1}{3}$ inch in three minutes; the second, $\frac{1}{2}$ an inch, and the third $\frac{3}{4}$, in one minute and a half. The experiment was then varied by placing another piece of the same dimensions in a freezing mixture at 17°, when it scarcely contracted at all, and was quite frozen in seven minutes. But when transferred to water at 120°, it slowly shortened from $1\frac{1}{2}$ to half an inch. In accordance with these facts, it was found by Mr. Clift, that by the application of hot water, the heart of a carp was made to contract eleven hours after decapitation—and that the muscles of another carp were thrown into a state of violent contractions by the same means, four hours after the brain and spinal marrow had been destroyed. Similar results were obtained by Mr. John Marshall at my request in 1840. For he found that, forty-five minutes after the vessels of the neck of a tortoise had been divided, the pulsations of its heart were augmented from nineteen to thirty-six per minute, on raising its temperature from that of his room to 90°—that on applying water cooled down to 60°, they were reduced to seven beats, but augmented to fifty-two on raising the water to 106°, and again reduced to twenty-two per minute, on cooling the water to 90°. The heart was then removed from the body, and exposed to the alternate influence of warm and cold water, with similar results, which were also observed on the heart of a salamander.

that this contraction is hastened by an elevation of temperature. Yet it seems never to have occurred to this great man, that caloric is the active principle in the blood; nor that if the temperature of the whole earth were reduced to 32° for any considerable time, there could not be a vestige of life on its surface.

Corresponding with the large amount of caloric derived from the atmosphere by the respiration of birds, the pulsations of the heart are stronger and more frequent than in mammalia, *ceteris paribus*,—varying from one hundred and ten, to one hundred and fifty, and even two hundred per minute, in the smaller and more active species. So rapid is their circulation, that when the vessels of the neck are divided, nearly all their blood escapes in about half a minute; but requires from one and a half to two minutes, in the dog, sheep, deer, hog, and other mammalia of the same size: whereas in man, whose mean temperature is several degrees lower, the pulsations of the heart are less vigorous and frequent. For it has been found to discharge about two ounces of blood from the ventricles at each beat, more or less, according to the energy of the constitution, size of the organs, &c.; so that if it contract seventy times per minute, it follows, that from twenty to thirty pounds of blood, or all which the body contains, must circulate throughout the lungs and general system in from two to

three minutes. But so languid is the circulation in reptiles and fishes, that when decapitated, or deprived of the heart, their cold, pale, watery, and imperfectly organized blood, oozes out by drops; and is often many hours in escaping from the system in sufficient quantity to destroy life, especially during cold weather.* Again: whenever the temperature of the human body is raised above the natural standard by immersion in the hot bath, the pulsations of the heart are augmented from seventy or eighty to one hundred and forty or more per minute, which is also the case during the hot stage of inflammatory fever. On the other hand, when reduced below the natural standard, as during the cold stage of fever, or by immersion in the cold bath, the force and frequency of the heart's action are greatly diminished. For example, it was observed by Dr. Currie, that on plunging a patient in water at

* Caldesi found that the heart of a tortoise contracted from thirteen to twenty times per minute; while Wilford observed that in the boa, the pulsations varied from fifteen to twenty-five per minute; and Fontana found them from ten to fifty in the frog. But their number and force depend on the temperature of the surrounding medium. For at 47°, Spallanzani observed the heart of a serpent to perform ten or twelve beats; but twenty eight or thirty beats when the air was at 65° and 70°. While others have found, that on the approach of winter, they are sometimes reduced so low as one beat in two minutes. And Dr. Whytt states, that on raising the temperature of a frog to that of the human body, its pulsations augmented from twenty-five to eighty-seven per minute.

36°, his temperature soon fell to 87°, when the pulse became nearly extinct. So greatly is the pulmonary circulation paralyzed in such cases, that very little carbon and hydrogen are given off in the air cells of the lungs ; the supply of animal heat by respiration is nearly suspended; and if the circulation be not speedily restored by the warm bath, the patient remains chilly for two or three days, even before an ordinary fire.

The same thing occurs during asthma, and that congested state of the lungs which exists in the early stages of tubercular consumption. It has also been observed, that during the cold stage of cholera, and some of the more malignant forms of algid fever, the temperature is often reduced from 10° to 20° below the normal standard, when the blood, even in the arteries, assumes a dark venous hue, and the general circulation is so far diminished, as to resemble the languor of cold blooded animals, with a frightful prostration of all the vital functions. What then would be the effect of resorting to the warm bath, during, or rather before, the commencement of the cold stage that ushers in nearly all diseases? The managers of the Royal Humane Society have already answered this question, by employing the warm bath in cases of suspended animation from exposure to mephitic gases, and from immersion under water. I have also found, that by remaining 40 minutes in a bath raised to 110°, the pulse was

elevated from seventy-two to one hundred and thirty beats per minute: and so permanent was its influence on the circulation, that the action of the heart was not reduced to its natural frequency for five hours. It is therefore manifest, that in all cases of languid circulation, from whatever cause produced, we should apply that remedy on which its healthy vigour depends. By means of the warm bath, we can arouse the circulation of the whole system; and when the stagnant blood is dark coloured, we can change it to a bright florid hue, accelerate its passage through the lungs, and thus augment the function of respiration; as will further appear when I come to treat of its therapeutical agency.

It now remains to inquire what impels the blood through the arterial capillaries, and causes its return through the veins to the right side of the heart. Magendie and many other Physiologists maintain, that both are owing to the heart's action alone, because they are diminished whenever the arteries which supply them with blood are secured by ligatures. But when the arteries are tied, not only is the supply cut off, but the blood no longer receives the vitalizing influence of respiration. That the office of the heart is to convey blood from the lungs to the arterial capillaries, cannot be doubted; but that it is not any further essential to the capillary circulation, would appear from the following facts:—

1. That the circulation of sap in plants,* and of blood through many of the lower animals which have no heart, is active during summer, checked by cold nights, and wholly arrested during winter:—2. That the circulation of chyle through the lacteals, and of lymph through the absorbents, is obviously independent of the heart's action; and like that of the blood, is in proportion to the healthy temperature of animals; being more rapid in birds than in mammalia; languid in cold blooded animals; and suspended in all by intense cold, or by arresting the supply of caloric by respiration:—3. That after decapitation and removal of the heart from rabbits, or placing

* I have been told that caloric cannot be the cause of circulation in plants, because the sap rises more rapidly in spring than summer, which is true enough. But this is owing first, to the empty state of their vessels and pores, induced by the long absence of sap; and secondly, to its rapid expenditure in the formation of leaves and flowers, on first beginning to rise. For the same reason, when the lacteal absorbents have been completely emptied by fasting, they take up chyle more rapidly than when in a state of repletion; while it is certain that when dry, the earth absorbs water far more rapidly by capillary attraction, than when saturated by repeated heavy rains. The above objection is therefore without any solid foundation. Nor has it ever been proved that the capillary circulation of animals is owing to contraction of their minute vessels. And it has been observed by Wedemeyer, that when they were made to contract by the injection of alcohol or vinegar into them, the flow of blood through them was retarded. The only view then which seems capable of explaining the phenomenon, is that of an attraction between fluids and solids, whether we call it capillarity, endosmose, exosmose, vital affinity, or by any other name.

a ligature around the aorta, the blood has been seen with a good microscope, to move with considerable velocity through the capillaries of the mesentery for thirty-five minutes, and in one case for an hour and a quarter, as proved by the experiments of Dr. Philip:—4. That in many cases after death, and apparent cessation of the heart's action, the large arteries have been found empty; all their blood having been conveyed to the veins by capillary attraction: and, 5. That after the amputation of a limb, and the stoppage of its capillary circulation, the motion of its blood may be restored, and carried on with considerable activity for fifteen minutes, by the application of heat, as proved by the experiments of M. Guillot. (Journal de Physiologie, t. xi. p. 170.)

It has been urged by De Saussure, Decandolle, Tiedemann, and others, that the circulation in plants and animals must be owing to a different cause from that of ordinary capillary attraction, because when their vessels are divided during the living state, sap and blood continue to flow from them; whereas the fluids drawn up by small tubes of glass and other dead matter are not expelled from their upper orifices. But it should be observed, that the force of capillary attraction, *ceteris paribus*, is always inversely as the diameter of the tubes, which are much smaller in plants and animals than any employed in our experiments. Hence the great force with which

the sap issues from the stump of a cut grape-vine, as shown by the experiments of Mirbel, who found it equal to the pressure of 34 inches of mercury.* And such is the *vis a tergo* generated by the capillary circulation of chyle and lymph through the absorbents, that when the thoracic duct of a dog is secured with a ligature below the subclavian vein, it has been known to burst from the pressure. In all such cases, the *vis a tergo* is generated by virtue of an attraction between fluids and their containing vessels; the former being plus, and the latter minus. The organic particles of blood are forced through the pores of the systemic capillaries, and combined with the several tissues, by virtue of the same attraction. And it has been found that the worn out particles of the solids are not taken up by the mouths only of the lymphatics, but are absorbed by the pores of their coats: and finally, that neither in plants nor animals is any contraction of their capillaries essential to their circulation.

* It has been long known, that when a plant is put in the ground, its roots will extend only in the direction where they can obtain nourishment; and that when placed in a dark room, with a hole in the wall to admit light, it gradually extends or grows in that direction. Nor is the latter fact more surprizing, than that solar influence should be the cause of growth throughout the vegetable creation.

CHAPTER IV.

Theory of Digestion, Sanguification, Coagulation, Secretion, Nutrition, Muscular Motion, Sensation, &c.

"The idea of vital forces may gradually become so clear and definite as to be available in science, and future generations may include in their physiology propositions elevated as far above the circulation of the blood, as the doctrine of universal gravitation goes beyond the explanation of planetary motion by epicycles."

WHEWELL.

In accordance with the prevalent doctrine of the schools, Dr. Prout maintains, that "the true and legitimate object of inquiry for the Physiologist ought to be, *not what the vital principle is*, but what it does, just as the laws and effects of gravitation are legitimate objects of inquiry, though we know nothing, *and probably never will know* any thing of the principle of gravitation." (Application of Chemistry to Physiology.) Such, however, was not the opinion of Sir Isaac Newton, who made repeated efforts to ascertain the cause of gravitation, cohesion, chemical affinity, and animal motion, all of which he referred to one and the same cause. Yet it is maintained by Berzelius, Tiedemann, Müller, Liebig, and more than a hundred other physiologists of the nineteenth century, that "the vital principle is a power

distinct from all the other powers in nature;" while Dr. C. Holland adopts the hypothesis of Bichat, Richerand, Magendie, Prichard, Fletcher, *cum multis aliis*, that "life is not a simple principle, but the result of compound principles and actions, pervading and common to every part of nature." (Laws of Organic and Animal Life, p. 355.) Alas! the contradictions and mysteries of science are scarcely less perplexing and prejudicial to the interests of mankind, than those of metaphysics and scholastic divinity.

> "For 'tis not only individual minds
> That habit tinctures, or that interest blinds;
> Whole nations fool'd by falsehood, fear, or pride,
> Their ostrich heads in self illusion hide."
>
> THOMAS MOORE.

The earliest theory of digestion that has come down to us is that of Hippocrates, who regarded it as a species of concoction analogous to the ripening of fruits by solar heat. The same view was adopted by Galen, and taught by nearly all his successors, down to the time of Paracelsus and Van Helmont, who referred it to the agency of an acid liquor, under the control of the *Archeus*, which was supposed to be endowed with intelligence, to direct the stomach when to allow its contents to pass into the duodenum, to give the alarm and cause it to expel whatever is noxious, and to preside over all those actions of the living body that constitute the *vis conservatrix naturæ.*

But I have already shown that the *Archeus* was only another name for the Φυσις of Hippocrates; while it is equally evident, that the *fermentation* and *maceration* of the chemical physicians were merely different names for *concoction*, which means an action produced by heat. With the exception of the mechanical physicians, who maintained that digestion is the result of *trituration* by the coats of the stomach, the chemical theory prevailed until the time of Boerhaave, who like a genuine eclectic, referred it to the united agency of *gastric liquor, nervous influence, and animal heat.*

Since the time of Boerhaave, physiologists have generally maintained that food is converted into chyme by the solvent power of gastric juice, but under the immediate influence of "the unknown vital principle," which some have identified with the unknown nervous fluid, and others with the equally unknown electric fluid.* That

* Those who have adopted the electrical theory of life, have vainly attempted the explanation of one mystery by resorting to another. And so highly developed is the organ of wonder, compared with the reasoning faculties, that in all ages, the mass of mankind seem to have entertained a profound reverence for what they did not understand, as if simplicity were not the highest attribute of excellence, beauty, and truth. It is also gratifying to the selfish pride of inferior minds, to perceive that there are mysteries which reduce the loftiest intellects to an equality with themselves. With such persons, the simplicity of a new discovery derogates from its importance, being apparently so clear and obvious, that they only wonder how it ever could have escaped their own sagacity.

nervous influence is not essential to the process, (further than as it governs the voluntary function of respiration,) has been sufficiently proved by the experiments of Brodie, Magendie, C. Holland, Mayer, Braschet, Leuret, and Lassaigne, who have shown that in the horse, dog, and rabbit, the nerves going to the stomach may be divided without arresting the secretion of gastric juice, or seriously retarding the process of digestion.

Nor have we ever had the slightest proof that electricity is essential to the process; for the experiments of Dr. Philip have been repeatedly proved to be fallacious, and therefore require no comment.* But that caloric is the principal agent on which the solvent power of gastric juice depends, would appear from a variety of considerations. 1. We have seen that digestion is far more rapid in birds than in mammalia, and more rapid in the latter than in cold blooded animals. 2. It has been proved by the experiments of Dr. Beau-

* The impression that electricity is in some way connected with digestion and all other vital phenomena, has been inferred from the fact, that the *Gymnotus*, *Torpedo*, and *Silurus*, have the power of communicating an electrical shock; and that after having imparted several shocks, the power of digestion is greatly diminished. But the circumstance alone of this power being confined to a very small number of animals, and these of a low grade in the scale of organization, proves that it is not essential to any of the vital functions,—that like the nauseous secretion of the pole-cat, and that of some insects, it was intended by nature merely as a means of defence. Besides, electrical fishes have always been found in warm climates, and cannot exert their peculiar faculty when exposed to a low temperature. It was observed by

mont, that when gastric juice is taken from the stomach, and kept in viols at the temperature of the body, it converts aliment into chyme; but that when kept below the temperature of 40°, it produced no further change than so much water. 3. That the digestive power in man is in proportion to the quantity of his respiration, which is augmented by moderate exercise and agreeable emotions, but diminished by repose and the depressing passions. 4. I also found that when the stomach is weak, digestion is wholly arrested by drinking half a pint of cold milk during winter, attended with flatulence, colic, and nausea, that lasted for above twelve hours. The danger of drinking cold water when exhausted by over exertion, is well known in warm climates, where it often destroys life suddenly. Dr. Beaumont states, that on giving to St. Martin a gill of water at 55° when the stomach was empty, its temperature was reduced from 99° to 70°, at which it

John Hunter, that the electric columns of the torpedo were largely supplied with blood vessels, and by Dr. Davy, that they are connected with the organs of respiration. It may therefore be inferred, without departing from the rules of philosophic induction, that such animals have the power of converting at will a portion of the caloric obtained by respiration into the temporary form of electricity. Nor is this more strange, than that the caloric of atmospheric vapour should be discharged in the concentrated form of lightning. Some have supposed that the lungs are positive, and the stomach negative; while others have prescribed copper and zinc filings, with dilute nitric acid, with a view of supplying the patient with galvanic electricity.

stood for a few minutes, and did not regain its normal standard until thirty minutes had elapsed. Cholera morbus, gastritis, enteritis, dysentery, and diarrhea, are often produced by cold drinks, ice creams, &c.

The next step in the process of assimilation by which aliment is prepared to nourish the solids, takes place in the duodenum, where the albumen, oily matter, and white globules of chyme are converted into chyle, by uniting with pancreatic juice and a very large proportion of bile—while the resinous or bitter portion of the latter combines with the excrementitious part of the aliment, to be conveyed into the intestines, being never found in the lacteals. But whenever the chemical function of the lungs is greatly diminished, and the temperature of the body reduced from 5° to 10°, as during the cold stage of many fevers; or even 20°, during the early stage of malignant cholera, and those algid forms of disease termed cold plague, the secretion of gastric liquor, bile, pancreatic juice, urine, perspiration, and other animal fluids, is almost wholly suspended.

During the progress of chyle through the duodenum and lacteals to the thoracic duct, it becomes further and further organized, or assimilated to the nature of blood. For it has been found that besides albumen, oily matter, and white globules, it contains more or less fibrin, that coagulates slowly. But it is not until it passes

through that wonderful laboratory of life termed the lungs, that it assumes the colour and vital properties of blood, which contains the proximate constituents of all the organs ready formed, including most of the secreted fluids. By giving off variable proportions of carbon and hydrogen, that unite with atmospheric oxygen, caloric is evolved, and a portion of nitrogen absorbed, by which chyle is transformed into living blood of a bright scarlet hue, its temperature elevated from 1° to 3° in the higher animals, and its solid particles augmented from three to four-fold, according to the analyses of Vauquelin, Tiedemann, Gmelin, Reuss, and Emmert. (Müller's Elements, vol. i. p. 566. Baly's translation.)

How transcendently beautiful is the mechanism by which grass, corn, fruits, and a multitude of aliments, all differing in their composition, are thus converted into the constituents of animals, endowed with the power of renewing their organization, and of maintaining the activity of all their functions. The art of man has scarcely yet succeeded in ascertaining the proximate constituents of gastric juice, bile, pancreatic liquor, chyme, chyle, and lymph. How then is it possible that he should imitate the exquisitely refined chemistry of nature by which blood is formed? We have not even approached the perfection of that amazing process of living combustion, by which the temperature of animals is main-

tained at a uniform standard,*—much less the admirable provision of nature by which just so much carbon and hydrogen are given off in the lungs, and just so much nitrogen absorbed, as are requisite for the formation of blood.

But that the caloric obtained from the atmosphere by respiration, is the organizing principle by which blood is formed, would appear from all the analogies of nature. In the first place, if it be true, that solar caloric is the cause of organization and growth throughout the vegetable world, animal heat must perform the same office in the higher grades of existence. As the abundance, diversity, and richness of vegetation, depend on the mean temperature of climates,—so will it be seen from the following table, constructed from the analyses of Prevost and Dumas, Denis, Le Canu, Berzelius, and Marshall, that the ratio of solid organic matter in the blood of different animals, is in proportion to the quantity of their respiration and mean healthy temperature, *ceteris paribus*,—being greater in birds than in

* By the discovery of such a method, including the combustion of all that valuable fuel which now passes off in the form of smoke, four-fifths of the capital now wasted in the creation of artificial warmth would be saved. And could we devise a method of conveying caloric through our dwellings, in a mode resembling that by which it is diffused through every part of the body from the lungs, in combination with arterial blood, the saving would be still further increased, an equable temperature maintained, and many of the diseases that afflict the human race prevented.

mammalia, greater in the latter than in reptiles,* and greater in reptiles than in fishes. In accordance with this fact, we learn from the accurate researches of Dr. John Davy, that the specific gravity of the blood in these four classes, varies in the following proportions :—

	Arterial.		Venous.
Turkey	1061	..	——
Lamb	1047	..	1050
Dog	1048	..	1053
Frog	1040	..	——
Cod fish	1034	..	——

But there is reason to believe from the experiments of Denis, Le Canu, Marshall, and others, that the ratio of fibrin and red particles, is higher in the blood of birds and mammalia, than was

* Prevost and Dumas found the blood of a tortoise, which had been five months in a state of lethargy, to contain 15·06 per cent. of solid matter, owing, as they rightly supposed, to the loss of a large proportion of water by exhalation or transudation. And it will be seen hereafter, that owing to the same cause, (transudation of serum or water,) the proportion of red particles is greater in many cases of malignant cholera, than during the most vigorous state of health. (Examin. du Sang. Ann. de Chim. et de Phys. vol. xxiii.) But Mr. Marshall was so kind as to perform some analyses at my request, which show that the blood of the tortoise, while in a state of activity, does not afford above 8 per cent. of solid particles, and that of the salamander about 7·54. It may therefore be presumed, that the blood of all young birds hatched without feathers, and of mammalia born with the eyes closed, whose power of maintaining their temperature by respiration, is for some days very imperfect, is less highly organized than at later periods, corresponding with the feebleness of all their vital functions.

represented by those of Prevost and Dumas. For on evaporating a mixture of arterial and venous blood of healthy pigeons to perfect dryness, by means of a moderate temperature, produced by a water bath, as in the process of Prevost and Dumas, Mr. Marshall obtained 20·41 per cent. of solid particles. There is also reason to believe, from the analyses of Denis, that the blood of the more active mammalia when in health and well nourished, is more highly organized than that of man. For with Prevost, Dumas, and Le Canu, he found the latter to average about 13 per cent.; while the blood of the dog, calf, bullock, and horse, afforded the mean of 16.40 per cent. of fibrin and hæmatozin; as might be inferred from the size of their lungs, mean temperature, and power of digestion, which I have shown to be greater than in man, *ceteris paribus*.* In accordance with the above facts, Denis found the proportion of fibrin in the mixture of arterial and venous blood of the fowl, to be 12 parts in 1000; while in venous blood of the horse, it varied from 5 to 6, and in that of man, from 2·9 to 4·3.

* Denis also found the blood of individuals with broad chests and great muscular power, to contain from 14 to 18 per cent. of fibrin and red particles; whereas in those of narrow chests, and feeble constitutions, they varied from 8 to 11 per cent. And as might be supposed from the larger size of the thorax in man than woman, his blood is richer in organic particles, in the ratio of 13·24 to 11·59, according to M. Le Canu. (Etudes Chimiques sur le sang humain, par Louis René Le Canu.) Coinciding with these

He further states, that the ratio of red particles in the human species, augments from infancy up to the adult state, but diminishes after the age of forty, up to seventy. (Recherches Experimentales sur le sang humain, &c. par Prosper. Denis.)

Table representing the Relative Proportions of Dry Coagulum, Albumen of Serum, and Water, found in the Blood of different Animals.

Names of animals.	Coagulum.	Albumen of serum.	Water.	Experimenters.
Pigeon, (v. blood.)	15·57	4·69	79·24	Prevost and Dumas.
Do. art. and venous.	20·41	4·69	79·69	Marshall.
Hen, venous blood	15·71	6·30	79·99	Prevost and Dumas.
Do. art. and venous.	16·10	4·50	77·00	Denis.
Duck, venous	15·01	8·47	76·52	Prevost and Dumas.
Raven, venous	14·66	5·64	79·70	Prevost and Dumas.
Simia Calitriche, v.	14·61	7·77	77·60	Prevost and Dumas.
Man, venous......	12·92	8·69	78·39	Prevost and Dumas.
Do. vena portæ....	11·44	8·44	80·14	Prevost and Dumas.
Maximum in Man, v.	14·84	6·76	77·86	Le Canu.
Do. in Woman, v.	12·99	7·84	79·03	Le Canu.
Average in Man, v.	13·24	7·81	78·93	Le Canu.
Average in Wom. v.	11·59	7·96	80·43	Le Canu.
Sang. temp. in Man, v.	15·85	4·85	76·92	Denis.
Maximum do. v. ..	18·87	5·23	73·30	Denis.
Lymph. temper, v.	9·27	5·90	82·00	Denis.
Do. minimum, v...	6·33	5·40	86·90	Denis.

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facts, M. Quetelet represents the lumbar strength of the male as greater than that of the female, during the early periods of life, in the ratio of three to two; and after full growth, nine to five; while at fifty years of age, it is one-third less in both. And it will be seen hereafter, that whatever diminishes the process of respiration, whether a diseased state of the lungs, (as in asthma, pneumonia, and phthisis,) low diet, loss of blood, the depressing passions, or protracted disease of any description, impairs the process of sanguification, with all the energies of life.

Names of animals.	Coagulum.	Albumen of serum.	Water.	Experimenters.
Guinea Pig, venous	12·80	8·72	78·48	Prevost and Dumas.
Dog, venous......	12·38	6·55	81·07	Prevost and Dumas.
Horse, venous	9·20	8·97	83·79	Prevost and Dumas.
Calf, art. and venous	9·12	8·28	82·60	Prevost and Dumas.
Sheep, venous	9·35	7·72	82·60	Prevost and Dumas.
Do. art. and venous	13·84	6·76	79·40	Marshall.
3 Kittens a day old	12·95	5·25	81·44	Marshall.
Young Puppies....	16·90	4·60	78·00	Denis.
Calf three weeks old	15·80	6·30	77·50	Denis.
Bullock two years old	17·40	5·00	76·30	Denis.
Horse	15·30	6·00	78·65	Denis.
Do.	16·80	6·50	75·50	Denis.
Sheep, venous	16·36	....	....	Le Canu.
Do. art...........	17·07	....	....	Le Canu.
Land Tortoise, a. & v.	8·02	6·90	85·02	Marshall.
Salamander, do. ..	7·54	6·16	86·80	Marshall.
Frog	6·90	4·64	88·46	Prevost and Dumas.
Trout	6·38	7·25	86·37	Prevost and Dumas.
Eel	6·00	9·45	84·60	Prevost and Dumas.
Loach	4·81	6·87	88·62	Prevost and Dumas.

From the analyses of Prevost and Dumas, Berzelius, Marcet, Denis, and his own, M. Le Canu represents the venous blood of man as composed of the following constituents:

Dry crassamentum............	130.8453	in 1000 parts
Albumen of serum	67.8040	
Salts,* oily, extractive, and other matters	10.9800	
Water......................	790.3707	
	1000.0000	

* The proportion of salts in the blood, depends on the quantity contained in the aliment; and it has been found that above one half of them consists of muriate of soda. But the office they perform in the functions of life is not well understood. Nor have the proportions of oily, phosphuretted, and extractive matters, found in the blood, been ascertained with precision.

He also estimates the crassamentum as composed of

Albumen	125.6373	in 1000 parts
Fibrin	2.9480*	
Colouring matter	2.2700	

From which it would appear, that the organic particles of blood are composed chiefly of albumen, with a small proportion of fibrin, both of which are radically identical, according to Denis. As an example of the highly complex character of their proximate constituents, we are informed by Liebig, on the authority of Mulder, that the equivalent of albumen, as it combines with oxide of silver, is 7447, and that of fibrin as it combines with hydro-chloric acid, the oxides of lead, and copper, —6361.† (Organic Chemistry, vol. i. p. 339.)

The blood of all animals is formed from the same primitive elements; but as the different orders obtain various quantities of caloric from the air by respiration, its organic particles vary in form and magnitude, being elliptical in birds,

* From twenty-two observations, he found the proportion of dry fibrin to vary from 1.360 to 7.235 in 1000 parts of human venous blood.

† Liebig observes, that the readiness with which the complex molecules of organic matter decompose, is owing to the large number of atoms that enter into their composition, and the numerous directions in which their attractions operate (p. 323). But I have shewn that the tendency of the primitive atoms to unite into complex molecules, depends on the quantity of caloric around their particles, as no other elements except oxygen, hydrogen, carbon, and nitrogen, are capable of entering into such complex combinations.—(see p. 517.)

and larger than in mammalia, yet larger in reptiles, fishes, and other cold blooded animals than in either.* The consequence of which is, that their whole organization exhibits corresponding variations. Nor is this more strange, than that the form of crystals, and the chemical properties of many bodies composed of the same ponderable elements in the same proportions, should vary according to the temperatures at which they are produced, or the quantity of caloric around their particles, and the number of atoms that compose

* Hence it is, that when the blood of mammalia is injected into the veins of birds, the latter die in a very short time; and *vice versa*—while the blood of reptiles and fishes is rapidly fatal to all the higher animals, in which the extreme capillaries are so small, that they cannot be seen without a good microscope; but may often be discerned with the naked eye in cold blooded animals. In regard to the colour of the red particles, nothing has been clearly ascertained, except that it is owing to an envelope surrounding white nucleii, from one-third to one-fourth the size of the blood corpuscles, according to Hewson; and which he supposed to be identical with the white globules of chyle. Some have referred their red colour to the presence of carbon,—others to iron or its oxide, because found united with the red particles, (in the ratio of about 2 drs. to 30 lbs. of blood,) or of 5·6 parts of the pure metal in 10,000 parts of blood. But as both of these substances are found in chyle, which is white, and as many bodies are red without containing either, we must look for some other explanation, connected more immediately with the function of calorification. For it is evident that the depth of colour is in proportion to the mean temperature of animals, being brighter in birds than in mammalia, yellowish in reptiles, and still paler in fishes, if we except the tunny tribe, (and a few others,) whose breathing apparatus is very extensive for their class; while in animals of a still lower grade, it is without any colour.

these particles. For it is self-evident, that whatever the organizing principle may be, it must determine the composition and arrangement of the molecules that form any part of the body,—modified, however, in an endless variety of ways by surrounding circumstances.

That caloric is the cause of sanguification, would further appear from the fact, that it is the obvious agent by which the eggs of birds, reptiles, insects, fishes, and all other animals, are gradually changed from the state of a semi fluid germ, into blood and the various organs of which they are composed—whether derived from the sun, by which the lower animals are hatched—from ordinary combustion, as in artificial incubation, or supplied by the natural temperature of the parent, as in the ordinary process of hatching birds. Dr. Theodore Schwann has shewn by a very careful series of experiments, that when surrounded by an artificial temperature at the proper standard, the development of the egg can proceed to a certain extent without oxygen, while surrounded with hydrogen or nitrogen, but not if exposed to carbonic acid. And some recent experiments of Mr. Towne, recorded in the fourth volume of the Guy's Hospital Reports, were by many persons thought to prove, that oxygen is not essential to the early developement of the chick *in ovo*. For he found that after eggs were surrounded with strips of thin and dense paper, dipped in albumen, and then smeared over with varnish, the

process of incubation went on without interruption, till the twelfth or thirteenth day, when kept at the temperature of 100°; and that the allantoid membrane was perfectly formed.*

Dr. Southwood Smith maintains, that chyle and venous blood are converted into the arterial state, by parting with carbonic acid and water in the lungs; in exchange for which, they receive oxygen and nitrogen. Müller also contends, that

* But in his able Lectures on Generation, (published in the Lancet, 1840,) Mr. Owen states, that when a solution of acetate of lead was introduced through an opening at one extremity of the shell, which was then carefully luted, covered over with paper dipped in albumen, and smeared with varnish, as in the experiments of Mr. Towne,—patches of black pigment, or sulphuret of lead, were discovered on the internal surface of the shell, after exposing the egg for some time to the influence of sulphuretted hydrogen. He therefore contends that this gas must have found its way through the different layers of paper dipped in albumen, because they were changed yellow; and, that air may percolate the coating of varnish, and afterwards find its way to the internal parts of the egg through the layers of paper. I have also observed that the blood going to the respiratory membrane is of a dark venous hue, and returns of a scarlet colour,—proving that, to a certain extent, it undergoes the same change as while passing through the lungs after leaving the shell. But we are greatly in want of additional experiments for ascertaining with precision, what amount of carbonic acid is thus generated and exhaled through the pores of the shell during the various stages of incubation,—in short, what is gained and what is lost. Wagner states, that during the first week, the egg loses five per cent. of its weight, thirteen per cent. the second week, and sixteen per cent. during the third week. (Elements of Physiology, p. 129, trans. by Willis.) But Mr. David Tod found the loss to vary from ten to fifteen per cent. during nineteen days incubation, whether the eggs were fœcundated or not.

oxygen combines immediately with the blood, and enables it to excite the various tissues. But if oxygen were the animating principle, it ought to excite the heart and other muscles to contract when removed from the body, which is not the fact; for when reduced to the temperature of 32°, it produces no more effect upon them than so much carbonic acid. And although electricity excites contractions for a short time, its influence is exceedingly partial, compared with the same agent in the form of caloric.

Moreover, it has been fully established by recent researches into the phenomena of generation and growth of the embryon, that in no case is arterial blood transmitted from the mother to the fœtus through the vessels of the placenta, which serves chiefly as a *reservoir* of nourishment, supplied by the mother, absorbed by the vessels of the fœtus, and converted into blood that is wholly different from that of the mother,—in short, that the embryon is nourished by the transudation of arterial blood from the vessels of the mother. But we have yet to learn in what way the blood of the fœtus is arterialized in the placenta, and whether oxygen is essential to the process.* This much, however, may be asserted with confidence, that it is not by means of oxygen, or any other *ponderable gas*, that the proximate constituents of

* Nor is there a single anatomical preparation in the Hunterian Museum, shewing whether the colour of the venous blood in the fœtus differs from that of the arteries.

the egg are converted into the blood and different organs of the chick, whether they be absorbed through the pores of the shell during the process of incubation or not; and that as the germ of viviparous animals is formed from an albuminous secretion, before any connexion is established with the circulation of the mother by means of the placenta, it can receive no oxygen from the maternal blood; consequently, that it must be developed by means of the same life-giving element (Ζωηφορον Πυρ) that actuates the universe, and fills it with beautiful creations: that causes the germination of plants, the circulation of sap, and its conversion into the various constituents of their substance while passing through the leaves, (where oxygen is not absorbed but given off;) and by which the Egyptians annually produce one hundred millions of poultry from one hundred and fifty millions of eggs, placed in a few large ovens. Should it still be urged that oxygen is indispensable to animal life, I answer, so is it to the movements of the steam engine, because by its chemical union with carbon and hydrogen in the furnace, as in the lungs, the moving principle is evolved; and, because like carbon, hydrogen, and nitrogen, oxygen is an essential constituent of animal bodies.

During the passage of dark venous blood through the lungs in combination with chyle and lymph, received from the thoracic duct, its temperature is elevated, its colour changed to a bright

florid hue, and its vital properties exalted. It has also been proved by the experiments of Prevost and Dumas, Denis, Le Canu, Mayer, Autenrieth and Letellier, that arterial contains a larger proportion of organic particles than venous blood; as might naturally have been inferred from the obvious fact, that during every circulation of the former through the general system, a portion of them is transferred to the solids. The relative proportions of fibrin contained in the arterial and venous blood of different animals, are stated by Müller, on the authority of Berthold, as follows:

	Arterial.	Venous.
Dog	666	500
Sheep	566	465
Cat	521	474
Goat	429	366

It was before shewn from the experiments of Dr. Davy, that the specific gravity of venous exceeds that of arterial blood. But, as if not aware of the fact, that the latter contains a larger proportion of fibrin and red particles; he observes, that the greater specific gravity of venous blood may depend partly on its containing less water, and more animal matter. (Anat. and Physiological Researches, vol. ii. p. 25.) He adds, "the use of the red particles, according to the views of Hunter, seems to be connected less with nutrition than with action, and more with the production of animal heat, than perhaps with any other function."

Is it then possible, after having proved by so many accurate experiments, that the temperature of blood is elevated from 1° to 3° while passing through the lungs, and reduced to its former state while passing through the general system, that this intelligent physiologist should have overlooked the fact, that arterial contains a larger proportion of organic matter than venous blood? And is it not admitted by all physiologists, that every part of the body is nourished at the continual expense of arterial blood? Dr. Edwards maintains that the temperature of animals depends greatly on the proportion of red particles in their blood, because the lower orders, in which it consists chiefly of water, are cold blooded. But this is only one among a thousand examples that might be adduced, of the manner in which men have inverted the laws of nature, or confounded cause and effect. For as the mechanical physicians, including Boerhaave and Haller, regarded animal heat as an effect of the heart's action, motion of the blood, and its friction against the solids; so did Sir H. Davy regard it as "a result of all the changes and organic actions that take place in animal bodies." And so effectually has the chemical theory of respiration been shaken by his denial that caloric is a material agent, that Mason Good " omits the consideration of it," while he defines " respiration as the act of receiving oxygen, and throwing out carbonic acid."

In a recent course of lectures published in the Lancet of 1840, by Mr. Ancell, the author maintains that animal heat results from "the molecular vital actions continually going on between the red particles and the liquor sanguinis." We are also told by Dr. Dickson, in a late work termed "Fallacies of the Faculty," that "animal heat results from the constant mutation and motion of all the organs"—which is only another mode of expressing the opinion of Sir H. Davy,—and of Bichat, who represents it as "a product of all the vital functions"—with this difference, that Dr. Dickson refers the mutation and motion of all the organs to electricity; but without explaining the *modus operandi* of this mysterious agent. Alas! it is much easier to expose, than to reform, the errors of the faculty. Nor is it any definition of life to say with Sir H. Davy, that "it consists in a series of corpuscular changes"—and with Dr. Roget, that "it consists in a series of actions and reactions,"—without explaining the cause of these corpuscular changes, actions, and reactions.

In regard to all the above hypotheses, I answer,—we might as well suppose that the temperature and power of steam are owing to the movements of the engine, as that animal heat depends on the action of the heart, friction, &c. —that the temperature of boiling water, and its conversion into the elastic or gaseous state, results from the vibratory or rotary motions of its

particles,—as that "animal heat results from the molecular vital actions of the blood"—that the temperature of spring, summer, and winter, depends on the actions which make up the movements of chemistry, geology, and life—or that the caloric perpetually radiated from the sun into the planetary spaces, and again returned to the fountain from which it sprung, depends on the motions of the heavenly bodies,—as that "animal heat results from the constant motion and mutation of all the organs."

If the vitality of the blood had not been recognised by all antiquity, and sanctioned by the universal common sense of mankind, down to the time of Harvey and Willis, it would still be evident from the well established fact, that all the organs are formed immediately from it; and that whenever its supply is cut off, they cease to live. It is therefore clear, that all the phenomena of the animal economy, whether in health or disease, must depend on the conditions of this important fluid, which, in accordance with the doctrine of Hunter, Bordeau has termed *liquid flesh*,—and that a complete knowledge of its vital properties is essential to any sound or rational system of medical theory and practice. It was justly observed by the celebrated Locke, that "to mind the solid parts of the body, and overlook inquiry into the fluids, especially the blood, were little less improper in a physician than it would be in a vintner to be

very solicitous about the structure of his cask, and neglect the consideration of the wine contained in it." (Essay on Human Blood.)

One of the most important facts connected with the vital properties of the blood, is the process of coagulation by which its fibrin becomes solid, when removed from the vessels, and unites the red particles into a mass of greater or less density. But the cause of this change remains an unresolved problem. As it must always have been known that inorganic fluids become solid under the influence of cold, it was maintained by Hippocrates and Aristotle, whose opinion was adopted by Harvey and Sydenham, that the coagulation of blood is owing to the loss of animal heat. For the first time in the history of science, this error was refuted by Hewson, who found that the process was always retarded by cold, and hastened by increase of temperature. He therefore concluded, that it was owing to the influence of atmospheric air. But as it was observed by Spallanzani to take place within the cellular tissue when extravasated, removed from the circulation, and not exposed to the air, he inferred that it was owing to the cessation of its motion. This opinion has also been refuted by the fact, that coagulation cannot be wholly prevented by agitation of blood out of the body. Yet it would appear from the experiments of Magendie, that it is greatly retarded by the natural movements

of the circulation : for when he connected a dead tube at the temperature of the body, with the extremity of a divided artery of a living animal, the blood sent into it remained fluid while kept in motion by the heart's action.

Some have ascribed the process of coagulation to the escape of carbonic acid, and others to the loss of nervous influence, or to the death of the blood. But it is now fully established, that it is not prevented by the presence of carbonic acid, nor when placed *in vacuo.* And that it is not owing to the loss of vitality, is evident from the fact, that in the latter stages of the most malignant diseases, the blood remains fluid after death. What then is the rationale of coagulation? To this important query Physiologists have hitherto offered no satisfactory reply ; and Dr. John Davy observes, that it must still be regarded as "one of the many mysteries of nature"—that "all we know is, that from a fluid state, the fibrin becomes solid, entangling a portion of red particles and serum." (Anat. and Physiological Researches, vol. ii. p. 2.)

The leading facts connected with the theory of coagulation may be reduced to the following propositions :

1. That the contractile power of the blood when removed from the body, like that of the muscular fibres, is in proportion to the quantity of respiration, mean healthy temperature, and aggregate

vital energy, in the different orders of animals; being greater in birds than in mammalia, and greater in the latter than in reptiles and fishes.

2. That as the temperature of arterial is higher than that of venous blood, so does the former coagulate more quickly and firmly than the latter.*

3. That as the vital energy of animals is always diminished by reducing their temperature below the natural standard, so is the coagulation of the blood retarded by the same means, and wholly prevented by long continued cold.†

4. That the blood of individuals belonging to the sanguine or dynamic temperament, coagulates sooner and more firmly than in such as are

* We also learn from the experiments of Hunter and Thackrah, that arterial resists putrefaction longer than venous blood. And Bellingeri states, that while the former is positive, the latter is in a negative state of electricity. However this may be, they are certainly *plus* and *minus* in relation to temperature, or the quantity of caloric in each, while circulating through the body.

† Sir Charles Scudamore found, that human blood which began to solidify in four minutes in air at 53°, underwent the same change in two minutes and a half at 98°, and in one minute at 120°:—again, that blood which coagulated firmly in five minutes at 60°, required seventy minutes to become solid when reduced to the temperature of 40°. Nor is it true, as stated by Mr. Ancell, on the authority of Mr. Prater, that when blood is suddenly raised to 140° and 150°, its power of coagulation is destroyed; for in numerous experiments of my own, it took place rapidly in the blood of sheep at all temperatures, from 110° up to 150°, and almost instantaneously, when the cups in which it was received were placed in water at 180°, owing, doubtless, in the latter case, to solidification of its albumen, which takes place immediately at temperatures above 156°.

of a weak or phlegmatic constitution; while its contractile power is diminished by whatever impedes the function of respiration, as in phthisis, asthma, disease of the heart, the cold stage of fever, and all maladies of long standing, by which the powers of life are greatly reduced.

As a proof of the first proposition, and corresponding with the highly organized state of the blood in birds, together with its bright florid hue, we are informed by Denis, that when poured from the divided vessels of a decapitated fowl, it coagulated almost instantaneously, and formed a very firm clot. Dr. Davy also states, that he observed the blood of a fowl to become solid in less than a minute at the ordinary temperature of the air; but when suddenly cooled to 40° by means of ice, in something less than three minutes. (Op. cit. p. 76.) He also found that the arterial blood of sheep and lambs coagulates much sooner than that drawn from the veins.* And it is generally known, that the blood of dogs, sheep, rabbits, and other active mammalia, (whose temperature is higher than that of man,) becomes solid in a shorter time; or in from one to three minutes in the former, and in from two to five minutes in the latter, during health.

Having ascertained that a mixture of arterial

* The same thing has been observed in the blood of birds and other mammalia, by Denis and Berthold; which I have also repeatedly witnessed in the slaughter house.

and venous blood of ducks and fowls began to solidify almost immediately, I performed the following experiment, with a view of discovering how far the process might be modified by reducing the temperature of animals. For this purpose, a healthy pigeon was immersed in water at 47°, with the exception of its head, when a thermometer *in recto*, fell from 108° to 74° in twelve minutes, and the poor bird presented all the symptoms of approaching convulsions, coma, and death. In this state it was decapitated, and its blood made to flow into three saucers, one of which was placed in water at 130°, another in water at 110°, while the third was exposed to the temperature of the room at about 60°,—when the blood in the first saucer began to solidify in three minutes, that in the second in four minutes, and that in the vessel at 60°, but slightly in seven minutes. Nor is it less worthy of notice, that when the blood of another pigeon was treated in the same manner, but without previously reducing its temperature, it coagulated sooner at 110° than at 60°, sooner at 130° than at either; and more firmly in five minutes, than the blood of the other pigeon at the expiration of thirty minutes. Nor is it more strange that caloric should determine both the fluidity and coagulation of blood, than that attraction and repulsion, contraction and expansion, should be modified effects of one and the same physical cause.

In another set of experiments, I found that when half an ounce of blood from the divided vessels of the neck in a healthy sheep was put in a small tin cup, and surrounded with a freezing mixture of snow and common salt at 17°, it began to coagulate slightly in two minutes and a half, increasing slowly till the end of five minutes, when the clot was very loose and imperfect; soon after which it began to congeal, and was quite frozen in fifteen minutes. In another experiment, the same quantity of blood was taken from the carotid artery of a vigorous sheep, (whose temperature was 106° in the left ventricle of the heart, and 104° in the right side,) and placed in a tin cup, surrounded with a freezing mixture at 0°, when it began to solidify just perceptibly in three minutes, and was quite frozen in six minutes. After remaining in this state above an hour, it was gradually thawed by exposure to the atmosphere, which was at 51°, and formed a loose coagulum. In a third experiment, three half pint cups were filled with blood from the neck of another sheep, one of which was placed in water at 130°, another in water at 100°, and the other exposed to the air at 51°; when they all began to coagulate in about one minute and a half, but that in the cup at 130° contracted more firmly in two minutes, than either of the others in five minutes.

Corresponding with the fact established by

Hunter, that the ears of rabbits, the combs of cocks, and the extremities of other animals, may be rigidly frozen, and afterwards restored to life, when gradually submitted to the influence of warmth, it has been demonstrated by the experiments of Hewson, Thackrah, Davy, Magendie, and Prater, that the blood of animals may be repeatedly frozen, and afterwards coagulate when thawed. Hence it is that hybernating animals, including reptiles and other cold blooded species, after being frozen for months, as in the higher latitudes, are restored to activity by the returning power of solar warmth. The influence of caloric on the coagulating power of the blood is further illustrated by the following observations of Dr. John Davy, who found that the blood of a tropical turtle, whose temperature was 91°, coagulated firmly in about two minutes: while that of another turtle, whose temperature was 84.5°, required five minutes to become solid; and that of another, whose temperature was 58°, required thirty minutes to coagulate firmly. (Anat. and Physiological Researches, vol. ii. p. 10.) Mr. Marshall also found that the blood of a tortoise whose temperature was 55°, that of the room being 58°, began to coagulate in eighteen minutes, and became solid in one hour and forty-five minutes. But that when raised to the temperature of 110°, (falling to 80°) it began in nine minutes and a half, and was completed in twenty

three minutes and a half. He further observed, that when raised to 130°, it did not commence before thirteen minutes and a half had elapsed, and was completed in one hour.

It is therefore evident that, within certain limits, the coagulating power of blood is augmented by raising its temperature above, and diminished by reducing it below the natural standard. As a further proof of this, it is stated by Müller, that during winter, the blood of frogs coagulates very imperfectly. And I may add, from several observations of my own during the winter of 1840-1, that blood of the eel and several other species of fish, requires from ten to fifteen and sometimes thirty minutes to coagulate in a very imperfect manner. Let us then reject the assertion of Magendie, that "blood coagulates alike at all temperatures from 10° to 156° F." The truth is, that notwithstanding the vast number of experiments performed by this celebrated physiologist, he seems never to have inquired how far the process of coagulation is modified by the difference between warm and cold blooded animals.*

* Yet we are greatly indebted to him for the light which his researches have shed on the influence of various medicinal agents on the vital properties of the blood, many of which, that are constantly employed in practice, disorganize its particles, and diminish or prevent its coagulation, out of the body. For example, he has shewn, that sulphuric, nitric, hydrochloric, oxalic, hydrocyanic, phosphoric, arsenious, and many other acids, in small proportions, either prevent or retard its solidification,—that it is retarded by

That coagulation is a vital process, analogous to that by which blood is converted into the different organs, and owing to the same cause which enables the muscles to contract, was fully recognized by John Hunter, who demonstrated, by an admirable series of experiments, that when effused into healthy divided parts, it becomes penetrated with innumerable vessels that may be injected by injecting the neighbour ingarteries,—causing wounds to heal by the first intention, and plugging up divided vessels.* He also maintained with Hewson, that the process of coagulation is accelerated by an increase of temperature, and retarded by cold ; that the colour and coagulating

solutions of opium, belladonna, strychnia, nicotin, sulphate of morphia, digitalis, aconite, hemlock, tartarized antimony, bichloride of mercury, nitrate of copper, and by nearly all the neutral salts, except in very small proportions, although most of the latter change it to a florid hue; and that while some of the above medicines precipitate the albumen of the blood, others dissolve its fibrin. Magendie has also shown, that by injecting seven grains of oxalic acid into the jugular vein of a dog, he was attacked with difficult breathing, small and frequent pulse, prostration of strength, followed by coma and death in a few hours; and that the same fatal effects were produced by injecting an ounce of the mildest neutral salts into the veins. (Lancet for 1839.)

* We also learn from the researches of Prevost and Dumas, that when a small quantity of blood from a living animal is immediately placed between thin pieces of talc, the red particles may be seen with a good microscope to arrange themselves in lines, or series and aggregates, that resemble chaplets of beads, (a process which must be regarded as an imperfect species of organization, and as the result of its last remainder of vitality.) (Ann. des Sciences Naturelles, tome xii.)

power of the blood are more expressive of disease, than any other part of the animal economy. (Treatise on the Blood, &c. vol. i. p. 135.) But he was wholly mistaken in supposing that coagulation is prevented in cases of sudden death from lightning, violent emotions of the mind, the more active poisons, and exhaustion from excessive muscular exertion, as has been recently proved by the accurate researches of Dr. John Davy.

At the same time, it is certain from the experiments of Hewson, that the coagulating power of the blood is diminished in all cases of congestion, intermittent fever, pneumonia, consumption, rheumatism, and various other modifications of disease, by which the general forces of life are seriously impaired,—and that the process is delayed in such cases, for ten, twenty, thirty, or even ninety minutes. It is very much protracted in cases of apoplexy, epilepsy, concussion of the brain, suffocation, strangulation, violent emotions of fear, and other depressing passions,* or what-

* It is very well known, that in cases of fright, the powers of life are remarkably diminished. That this is owing to partially suspended respiration, on which the vital properties of the blood depend, is evident from the coldness of the extremities, langour of the circulation, paleness of the skin, and darkness of the blood, when drawn from a vein. In all such cases, the voluntary power of the brain is more or less impaired by the shock, and its command over the lungs so far diminished, that their chemical function is greatly interrupted, when they fail to arterialize the blood

ever diminishes the chemical function of the lungs, and consequently, the vital properties of the blood, or the process by which it is organized. We also learn from the researches of Denis, Le Canu, and other physiologists, that in all chronic diseases, such as chlorosis, scrofula, diabetes, scurvy, diarrhea, &c. the blood coagulates slowly and imperfectly, while in the worst forms of typhus, yellow fever, plague, malignant cholera, tetanus, and hydrophobia, it scarcely takes place at all, towards their fatal termination. And it is worthy of notice here, that during pregnancy, by which a portion of the vital energy of the mother is expended in support of the fœtus, her blood coagulates more slowly than at other periods, giving time for the red particles to subside,—thus causing the fibrin to contract by itself on the surface, and to present the appearance of a whitish crust, termed the buffy coat, which is generally witnessed in

in a proper manner. Accordingly it was observed by Hewson, that whenever the pulmonary circulation is much impeded, the blood first drawn did not coagulate for ten or fifteen minutes; but that after the congestion of the weakened and overloaded capillaries was removed by taking away a few ounces of blood, it flowed from the orifice more freely, changed from a dark to a bright florid hue, and coagulated in from three to five minutes. It has also been observed by others, that blood which exhibits a bluish tint while flowing, always coagulates more slowly than usual, and afterwards exhibits the buffy coat. I have further observed, that when chickens and rabbits are decapitated under the influence of fright, the blood is more dark than usual, and requires a much longer time to coagulate.

the blood drawn during nearly all cases attended with slowness of coagulation, excepting those that are marked by a great loss of vitality, and general prostration of the system.

It has been maintained by many physiologists, including Scudamore and Müller, that the relative proportion of fibrin in the blood is augmented during inflammation, and that this is the cause of the buffy coat,—an opinion which has been completely refuted by Dr. John Davy, who has shown that healthy blood contains more fibrin than in cases of inflammation. But although he admits that "very buffy blood is very slow in coagulating," and that in healthy blood the process is rapid, he maintains with Hewson, that in some cases, owning to a thinness, tenuity, or liquidity of the fibrin, the red particles may subside from one-eighth to one-fourth of an inch in two minutes, and sufficiently to cause the buffy appearance. (Anat. and Physiological Researches, vol. ii. p. 43-6.)

The true state of the facts is, that in all cases of protracted disease in which the chemical function of the lungs is seriously deranged, the proportion of both fibrin and red particles is more or less diminished, as proved by Denis and Le Canu, and the process of coagulation retarded; while it is equally certain, that in the early stages of inflammation, congestion, fever, and other forms of disease, in which the function of respi-

ration has been deranged only for a short time, the contractile power of the blood may be greatly impaired without much, if any loss of fibrin.

In opposition to the well established fact, that in persons of the sanguine temperament, with a broad and full chest, the blood coagulates quickly and firmly, as in all the more powerful mammalia, and still more so in birds, whose vital energy is vastly greater, *ceteris paribus*,—that in persons belonging to the phlegmatic temperament, and in the various species of cold blooded animals, the process of coagulation is imperfect,—it has been recently maintained by Mr. Ancell that " blood coagulates most rapidly in weak animals, in weak states of the constitution, and in diseases of debility"—that " when the blood is a long time in coagulating, its contractile power is strong, corresponding with the vigour of the constitution." (Lectures on the Blood, Lancet, Jan. 1840.)

This extraordinary declaration, so inconsistent with the analogies of nature, and which the intelligent author has offered as a general axiom, seems to have been founded on the observation of Hewson, Dr. Davy, and others, that the blood of animals exhausted by excessive hemorrhage, and by long continued muscular exertion, coagulates much sooner than when taken from the vessels in a healthy state. In regard to the cause of this apparent exception to the general laws of

Physiology, no adequate explanation has been offered. All parties agree, that it is a beautiful provision of nature to arrest hemorrhage, by plugging up divided vessels. When it was proved by the analyses of Prevost, Dumas, Magendie, Denis, and Le Canu, that the proportion of fibrin is always diminished by loss of blood, the rapidity of its coagulation was referred by some to an excess of serum, or of saline matter. But we have seen that in cases of protracted disease, the serous portion of the blood is augmented in relation to the quantity of fibrin and red particles, while its coagulation is both slower and weaker than in health.

The fact is, that although the blood of an animal exhausted by over exertion, like the last running of blood in cases of excessive hemorrhage, coagulates almost instantaneously, the crassamentum is always loose and infirm. There is reason to believe, that the rapidity of the process is owing partly to diminished motion and vitality of the blood ; and that, like the rigidity of the muscles after death, it depends on the last remains of contractility, as will appear from the following facts. In the first place, it is well known, that when blood is extravasated, and its motion arrested, as in uterine hemorrhage, and in cases of ecchymosis, it very soon coagulates, although surrounded with living parts ; while it is equally certain, that the action of the heart and general

activity of the circulation, are greatly diminished by loss of blood. Secondly, it is well known to butchers, that in animals exhausted by over exertion, rigidity of the muscles comes on *much* sooner after death, and their blood coagulates *much* more rapidly, than if slaughtered in vigorous health. I have also observed that in a sheep which had been exhausted by travelling to market, the extremities were cold, the circulation exceedingly languid, and the muscles stiff, even *before death.* In accordance with this fact, I found that when an ounce of its blood was received from the divided vessels of the neck, it became solid in half a minute. It is therefore probable, that when the motion and vitality of the blood are thus diminished, *the process of coagulation may actually commence, though imperceptibly, before it leaves the vessels;* (just as water begins to congeal insensibly at 39°, but does not become solid till reduced to 32°;) *and for the same reason that the muscles become stiff before death.*

It is stated by Richerand and Orfila, that in cases of sudden death while in the full vigour of health, caused by suffocation in the mephitic gases, the temperature and flexibility of the muscles remain for several hours after death. And it is certain, that whatever may be the cause of the *roideur cadavérique,*—whether mechanical, chemical, or vital—and whether it be owing to coagulation of the blood, as supposed by Orfila,

Beclard, and Treviranus—the contractility of the muscles continues only so long as their temperature remains above that of the surrounding medium, and wholly ceases whenever the body becomes cold,—for if the limbs be then flexed, they do not again become rigid. Müller relates on the authority of Nysten and Sommer, that rigidity begins in fifteen or twenty minutes after death from lingering maladies, in which the powers of life have been greatly exhausted—that it commences sooner in infants and very old people than in robust constitutions, or in such as have been carried off by violence in the full vigour of health, without loss of blood,—in which it does not come on for several hours after the circulation has ceased, and remains for a proportionably longer time. It has been also said, that after death from exposure to intense cold, (in which the rigidity commences *before* death,) it is completed very soon afterwards—and that in a case of tetanus, the spasmodic contractions passed immediately into the rigidity of death. But that it consists of the last remainder of vitality, is evident from the fact, that it always disappears before putrefaction begins, and its duration is shortened by whatever diminishes the previous forces of life.

In accordance with the opinion of many modern physiologists, Cuvier represents the process of nutrition, by which blood is converted into the

different organs, as the greatest mystery of life. And Sir Charles Morgan observes, that "the conversion of arterial into venous blood is a process involved in the deepest obscurity"—that "whether any single element is abstracted where the change takes place, or whether the alteration depends upon a change of disposition in all the elements among themselves, cannot even be guessed." (Philosophy of Life, p. 145.)

But we have already seen, that during the passage of dark venous blood through the lungs, in combination with chyle and lymph, variable proportions of carbon and hydrogen are given off, and unite with atmospheric oxygen, in exchange for which caloric is received, with more or less nitrogen, according as the aliment contains more or less of that element,—that during the transition of blood through the pulmonary tissue, its temperature is elevated from 1° to 3°, its colour changed to a bright florid hue,* its specific gravity diminished, the proportion of its organic particles augmented, and all its vital properties exalted. In this state, it excites the left ventricle of the

* Hippocrates seems to have been fully aware, that the temperature is higher in the left ventricle of the heart and aorta, than in the right ventricle or vena cava. He also observes, that the heart is the well known fountain of the aorta, which is connected with the lungs by the trachea, which he regarded as the upper extremity of the aorta. (περι Φλεϐον, i. ii.—περι Αρκον, vi.—περι Καρδιης, vii. viii.) But so little did this greatest of the ancient Physicians know in regard to the true theory of respiration

heart to contract, by which it is impelled into the ultimate tissues of the whole body, where the caloric just received in the lungs, together with a portion of arterial blood, percolate the delicate coats of the capillaries, unite with the solids by vital affinity, and form the various secretions by glandular action.

As proofs of what has just been stated, the temperature, vital activity, and renovation of all the organs, are constantly maintained at the expense of arterial blood, during its conversion into the venous state, while passing through the systemic capillaries, where its temperature is reduced, the number of its organic particles diminished, and its power of sustaining the healthy state of the different functions is greatly impaired,—when it returns to the lungs for a fresh supply of organic particles, and of living fire. If the temperature of the blood were not raised above that of the solids while passing through the lungs, there could be no transition of caloric from one to the other

and sanguification, that he speaks of the former as a cooling process; while he referred the dark or livid colour of what we call venous blood, to the contraction of the heart, and the rubicund or florid hue of what is now called arterial blood, to its dilatation. And so little did he know in regard to the office of the brain, that he represents the mind (γνωμη) of man as seated in the left ventricle of the heart. But as Pythagoras, Anaxagoras, Democritus, and Heraclitus, regarded the brain as the organ of mind, it may well be doubted whether Hippocrates was the real author of the Treatise ascribed to him, on the Heart.

—no combination of its proximate constituents with the membraneous, bony, muscular, and nervous tissues. Nor could chyle and venous blood be converted into the arterial state, without giving off carbon and hydrogen in the lungs, by which caloric is evolved, the temperature of the blood elevated, and its composition renewed.*

Should it be urged, that arterial contains more oxygen than venous blood, I reply that the difference is very small, and wholly disappears in the lungs, on giving off carbon and hydrogen, where venous becomes arterial blood,—that although it be true that the latter has been found to contain a little more oxygen, and the former a little more carbonic acid, as observed by Magnus,

* It is therefore not true, as maintained by Dr. John Davy, that "the object of respiration is to introduce oxygen into the blood, and separate carbonic acid from the blood"—that "animal heat is owing to the fixation of oxygen in the blood in the lungs, and to the combinations into which it enters in the circulation, in connexion with the different secretions and changes essential to animal life." For if it be a fact, which *he* has clearly demonstrated, that the temperature of blood is elevated while passing through the lungs, and diminished while passing through the general system, animal heat must be evolved in the pulmonary air cells, where the carbonic acid is generated, and there unite with the blood, from which it is given off to the different organs. Nor is it true, as maintained by Dr. Stephens, that arterial blood is changed to the venous state, by acquiring carbonic acid in the systemic capillaries, and again arterialized by the attraction of atmospheric oxygen for carbonic acid, and the abstraction of the latter in the lungs—much less, that arterial blood owes its colour and vital properties to the salts contained in the serum; because they exist in chyme and chyle, which are white.

on placing them in an exhausted receiver, those gases exist in a state of merely mechanical mixture, and not as organic constituents of the blood. Besides, it has been shown by the microscopic observations of Müller and others, that the form and magnitude of the red particles are the same in arterial as in venous blood. Nor has there ever been the slightest proof that oxygen causes arterial blood to unite with the solids while passing through the systemic capillaries,—nor that carbonic acid is there received, as it changes to the venous state. We are then bound to conclude that the difference between arterial and venous blood is owing chiefly to the greater amount of caloric and organic matter in the former. It has also been shown in a preceding chapter, (p. 552,) that when the blood of a living artery is confined between two ligatures, or in glass tubes hermetically sealed, it assumes all the properties of venous blood, without the loss of anything except caloric. Moreover, it is manifest, that if the composition of the solids be renewed, and their temperature maintained, at the expense of arterial blood, while the latter is changed to the venous state,* and deprived of its nutritive properties,

* Physiologists have often asserted, that the paralyzing influence of venous blood when sent to the brain, stomach, and other organs, is owing to some poisonous property which it acquires while circulating through the capillaries. But that its fatal influence is merely negative, owing chiefly to the loss of vital heat in the ultimate tissues, and not to any positively noxious influence, would appear from some experiments of Dr. Kay, (recorded in

there is no conceivable method of explaining the transmutation of one into the other, without admitting, that nutrition consists in the transfer of vital heat and organic particles from arterial blood to the solids.

The principal mystery connected with the process of nutrition, is the law of elective affinity by which the proximate constituents of the blood unite with their respective tissues. This much, however, is certain, that if the temperature of the blood be not raised above that of the solids, there could be no transition of caloric from one to the other,—no combination of fibrin with the muscles,—of albumen, oily, phosphuretted, and other matter, with the brain and nerves,—of albumen with the membranes, ligaments, and cartilages,—nor of lime with the bony textures. The proof of which is, that after the temperature of arterial blood has been reduced to an equilibrium with the solids, and its properties changed to the venous state, it fails to nourish the brain, nerves, muscles, and other tissues,—to maintain their temperature and specific modes of action, and to elaborate the various secretions. The inference is therefore obvious, that animal heat is the agent

the 28th vol. of the Med. and Surg. Journal,) who found that after a limb had been paralyzed by depriving it of arterial blood, its contractility was partially restored by the influx of fresh venous blood,—which was doubtless owing to the fact, that fresh venous blood contains more caloric than the solids, even at the same temperature.

by which these vital affinities are produced, and the activity of the various tissues maintained. Nor is this any more remarkable, than that the chemical union of water with the aromatic constituents of tea, coffee, medicinal infusions, and many other bodies, including the various salts, should be owing to the transition of caloric from one to the other. Nor is it more strange, that the caloric disengaged in the lungs during respiration, should there convert chyle into blood, than that the same active principle should cause oxygen and hydrogen to unite in the formation of water, or that solar caloric should determine all the chemical and vital transformations of the vegetable world.

Moreover, that animal heat is the cause, and not the effect of secretion, as maintained by Philip and many others, would appear from the following undeniable facts :—1. That the secretion of perspiration is much more copious during summer than winter, and in tropical than in the higher latitudes; while it is known to be greatly augmented by the high artificial temperature of glass works, foundries &c.* and that sweating is

* Dr. Southwood Smith found, that workmen who are exposed to the intense heat of the London gas works, lose from two to five pounds of perspiration in the space of one hour, twice a day, making the aggregate from four to ten pounds,—during which they consume enormous quantities of malt liquors. (Philosophy of Health, vol. ii. p. 396.)

the natural termination of the hot stage of fever: 2. That in cows, goats, and other domestic animals, the secretion of milk is more abundant during summer than winter, especially in cold climates, and that the growth of all young animals is greatly retarded by cold weather, unless they be protected by suitable shelter:—3. That the menstrual secretion, like that of the skin, is checked by exposure to cold damp air, getting the feet wet, by wearing too thin garments, and by whatever causes the abstraction* of vital heat from the system more rapidly than it is obtained by respiration; or whenever the latter process is diminished by the depressing emotions of grief, fear, and anxiety, which are attended with cold extremities, languid circulation, and a general loss of vital energy:—4. That as the quantity of secretion throughout the vegetable world is always in proportion to the heating influence of the sun, and wholly arrested during winter—so are all the secretions of animals during health, in proportion to the amount of caloric they derive from the at-

* The menstrual secretion also diminishes from the tropical regions, where it amounts to twenty-four ounces, and sometimes more or less, to the warm climate of Greece, where, according to Hippocrates, the average is twenty ounces; whereas in the middle latitudes of Europe and America, it does not exceed six or eight ounces, and not above three or four in the Polar regions. As might be inferred from this difference, the women are said to be more amative in warm than in temperate, and least so in frozen climates, where sensibility is at zero.

mosphere by respiration, and wholly arrested or greatly diminished whenever the temperature of the body is reduced much below the normal standard by immersion in cold water, or during the cold stage of fever, cholera, &c.—5. That if the temperature of blood be not raised above that of the solids, it cannot excite the stomach to secrete gastric juice, nor any of the other glands their respective fluids.

Again; that neither secretion nor nutrition depend on nervous influence, is evident from the fact, that the germs of all animals are generated by secretion, and developed by nutrition, before any part of the nervous system is formed, as stated in the preceding chapter, p. 592. Yet we are informed by Dr. Roget, in an article on Animal Physiology, contained in the Library of Useful Knowledge, p. 92, that " the nervous system exerts a certain action upon the blood, by which are maintained the secreting and other assimilating processes, a disengagement of caloric produced, and the temperature necessary to animal health sustained." He also adds in his late elaborate Bridgewater Treatise, that " not only muscular contraction, but the organic affinities which produce secretion, and all those unknown causes which effect nutrition, development, and growth of each part, are placed under the control of the nervous power." (Vol. ii. p. 357.)

Similar views have been offered by Tiedemann,

who observes, that "perhaps an imponderable fluid, resembling galvanic electricity, is generated in the nerves, which causes changes in the blood, passes through the delicate net work of the glands, and renders them capable of secreting, as supposed by Wollaston, Berzelius, Brodie, Philip, and others." (Comparative Physiology, p. 207.) And so far has Dr. Southwood Smith been fettered by this obscure hypothesis, that in his excellent work on the Philosophy of Health, he represents "the repulsive power of the blood on which its fluidity depends, as a vital endowment, derived, *probably*, from the organic nerves, so abundantly distributed to the coats of the blood vessels;" while in another place he maintains that "secretion is effected by means of the electric fluid, conveyed to the different organs by the ganglionic nerves." And although he admits, that the temperature of arterial is somewhat higher than that of venous blood, he observes that the difference is so slight, that in the general theory of animal heat it may be disregarded. (Vol. i. p. 347. Vol. ii. pp. 147—213—326.)

Is it then possible that physiologists are in doubt whether the fluidity of the blood is owing to the same cause which determines the fluidity of the ocean? Or is it possible that the Author of Nature would have ordained that the temperature of arterial should be higher than that of venous blood, if the difference were not essential to the well

being of the animal economy? The truth is, that this "slight difference" constitutes one of the most important facts connected with the whole theory of Physiology, Pathology, and Therapeutics. In accordance with the views of the ancients, who believed with Homer, that "strength is derived from spirits and from blood,"—it is now completely established, that the contractile power of the muscular system, whether voluntary or involuntary, is directly in proportion to the quantity of arterial blood with which they are supplied, and the rapidity of its circulation through them. But that caloric is the spirit on which its power of maintaining their activity and strength depends, is manifest from the facts already stated, that if the temperature of the blood be not raised above that of the solids, while passing through the lungs where it is formed, it cannot unite with their substance; and that whenever the general system is reduced below the natural standard by the abstraction of its vital heat, or by a deficient supply of it by respiration, all the energies of the animal machine are proportionally diminished.

On the other hand, whenever the temperature of the living body is raised much above the natural standard, so that the solids are brought nearly to an equilibrium with that of the arterial blood, the operations of secretion and nutrition are nearly suspended, and all the energies of life proportionally diminished. The reason of which

is, that under such circumstances, there is very little caloric transferred to the solids in combination with the blood, which therefore returns to the right side of the heart, of nearly the same temperature, florid hue, and quantity of organic particles, as when it left the lungs. Hence it is, that when the system is raised above the natural standard, as during immersion in the hot bath, or surrounded by an atmosphere from five to ten or more degrees above the healthy temperature of the body, as in the tropical portions of Africa, India, New Holland, and South America, during the heat of the day, all the powers of mind and body are prostrated, attended with syncope, apoplexy, and frequently death, if not relieved by cooling ablutions, by which the system is reduced to its natural *plus* and *minus* condition of arterial blood and of the solids. For it is a certain fact, that without this essential condition, none of the vital functions could be carried on.

The dynamical agency of caloric is not less essential to the movements of a steam engine, than to the muscular power of animals, and the activity of all their functions. In both cases, it is obtained by the combustion of carbon and hydrogen. In the former, it is evolved in the furnace, communicated to the boiler, where it unites with water, and converts it into an elastic gas, which, by acting on the piston, sets all parts of the machine in motion,—whereas in the latter, it

is disengaged in the lungs, where it converts chyle and lymph into the proximate constituents of blood, and raises its temperature, by which the heart is excited to contract, and send the vital stream to all parts of the animal system. And as the power of steam to move the piston is destroyed on parting with its caloric in the condenser, so is that of arterial blood to maintain the action of the heart, stomach, brain, and voluntary muscles, diminished or destroyed by parting with the caloric it receives in the lungs, while passing through the ultimate tissues of the body, which cannot be nourished and vitalized by dark venous blood,—for the simple reason, that its temperature has been reduced to an equilibrium with that of the solids, and its vital properties impaired, until again renovated by respiration.

Thus it is manifest, that when stripped of all hypotheses, and reduced to its utmost simplification, the science of animal physiology may be reduced to a very small compass,—that a difference between the temperature of arterial blood and that of the solids is absolutely essential to all the phenomena of life,—that the transformation of blood into the different organs depends on the same attraction of fluids for solids that determines the growth of vegetation, and the capillary circulation in animals that have no heart, like that of the lacteal and lymphatic absorbents. But why should I waste time in maintaining a doctrine

that requires only to be once fairly stated, to give it the force of a self evident truth? I answer, that, such is the influence of " stone blind custom," in obscuring the perceptions of mankind, that they generally disregard the plainest facts, when not in accordance with established systems, however unsatisfactory the latter may be,—that it is therefore often necessary to insist upon the clearest propositions—to " add line upon line, and precept upon precept," until the light of common sense shall penetrate the thickest crust of prejudice, and dispel the mists of error that have so long dimmed our intellectual vision.

The finest specimen of mechanism ever yet devised by the skill of man is the steam-engine, which is destined to augment the power of producing wealth and happiness a hundred fold. But as the grandest inventions of human genius are only feeble imitations of nature, (which Plato beautifully termed *the art of God,)* the process of living combustion is absolutely perfect, and the power thus obtained, applied with the admirable wisdom and efficiency that characterize all the operations of the Divine Architect. For in addition to the large amount of caloric that is wasted by imperfect combustion in the furnace of a steam-engine, including what is lost by radiation, or passes off with smoke, there is a great loss of power, owing to its being applied only to the piston ; whereas, in the animal machine during

health, and where the climate is temperate, there is no waste of caloric, which is conveyed and applied directly to every part of the body, in combination with arterial blood, by which, the composition and vitality of all the organs are renewed, while they are endowed with the faculties of motion, sensation, and the exalted attributes of intelligence.

As an example of the difference between the dynamical effects of ordinary combustion, and that of the living frame, we are informed by Mr. Thomas Wickstead, that during the consumption of 100 lbs. of small Newcastle coal, in the furnace of the best Cornish steam-engine, a power is generated equal to the elevation of from 82,000,000 to 113,500,000 lbs. a foot high, making an average of above 97,500,000 lbs. and nearly double that of Watts' engine with the same amount of coal.* But according to the mean result of experiments performed by Emmerson, Desaguliers, Bolton and Watt, Smeaton, Bevan, Wood, Tredgold, and Leslie, as reported in the Journal of the Franklin Institute, the tractive power of a first-rate English dray-horse is equal to the elevation of 16,500,000 lbs. a foot high in eight hours, when fully exerted. Yet a horse living on 12 lbs. of farinaceous food per day, cannot consume above

* He further states, that nearly 8 lbs. of coal per hour are required to generate a steam power equal to the muscular strength of one horse.

6 lbs. of carbon and hydrogen by respiration in twenty-four hours, and perhaps about 3 lbs. during eight hours' vigorous exercise. From which it follows, (if these data be an approximation to the truth,) that thirty-three such horses would consume about 100 lbs. of carbon and hydrogen by respiration in eight hours; and that they would generate an aggregate force equal to the elevation of 550,000,000 lbs. a foot high, or above five times what is created by the combustion of 100 lbs. of coal in the furnace of a Cornish engine.

In every description of mechanism, the power generated is always directly in proportion to the quantity of the impelling agent, ceteris paribus. As the velocity of a steam-car depends on the amount of caloric communicated from the furnace to a given quantity of water in the boiler, and thence to the piston,—so is the locomotive power of animals determined by the amount of the same active principle imparted to blood in the lungs, and thence to every part of the body. Nor is this any more remarkable, than that the velocity of planets through their orbits, like all the changes and transmutations which make up the history of chemistry and geology, should be directly in proportion to the heating influence of the sun.

But as it is an universal law of nature, that the cause of force is always expended in producing motion, the caloric which is employed in uniting

the proximate constituents of blood with the different organs, and in maintaining their healthy activity, is carried off and removed from the system,* with a rapidity corresponding with the energy of the brain, muscles, stomach, &c. until the vital affinities by which the molecules of arterial blood are transferred to, and kept in a state of combination with, the solids, is gradually diminished, and finally dissolved—when, having performed the office of renewing the structure and vitality of the different tissues, they successively fall from their places, and are taken up by the lymphatic absorbents, which convey them into the general circulation as worn-out materials,

* The caloric conveyed to the different glands in combination with arterial blood, and in elaborating the various secretions, is also expended by their action, when it passes out of the body with the exhalations from the skin, lungs, and kidneys, or from the surface by radiation. Were it not for this rapid expenditure of blood and vital heat, the temperature of birds would be far higher than it is, and their blood proportionally richer in organic particles;—for we have seen that they consume at least double the ratio of oxygen and of aliment as the same weight of mammalia. But as the functions of circulation, secretion, nutrition, and muscular motion are more energetic in birds, their blood and animal heat are transferred to the solids, and expended in maintaining the renewal of their composition and vital force with such rapidity, that their mean temperature, and the ratio of organic particles in their blood, are not much higher than in mammalia. For the same reason, the temperature of a man with large thorax and sound lungs, does not much exceed that of one with a narrow chest, diseased lungs, and imperfect respiration,—because in the former, it is more rapidly expended by secretion, nutrition, sensation, and locomotion.

to be again renovated in the lungs, and finally removed from the system by the several emunctories; while their places are immediately taken by fresh organic particles that are continually supplied from the living fountain of arterial blood.

Thus we perceive, that the vital energy of the brain, nerves, stomach, muscles, and all other parts of the body, is maintained by the successive additions of new matter, which no sooner unites with the different tissues, than it begins to die;—that when the caloric by which the particles of arterial blood are united with the solids, is expended by their action, their vital attraction begins to diminish;—that no healthy individual preserves his absolute identity for a single moment;—that every part of the body is in a state of perpetual motion, and transition from life to death, of organization and disorganization, renovation and dissolution;—that whenever the worn-out particles are not replaced by new and living ones, emaciation ensues, and all the powers of life decay;—in short, that whenever the process of nutrition is arrested, death speedily closes the scene.

It has been repeated a hundred times by different physiologists, that the affinities of life are superior to those of dead matter.* That this is

* It is also maintained by nearly all physiologists, that the cause of vital action is different from that of chemical affinity, cohesion, &c. because we cannot combine the elements of oxygen,

actually the case, would appear from the rapidity with which birds and mammalia convert the constituents of dead matter into blood and their respective tissues; and from the fact, that a strong man has been known to lift about ten times his own weight from the ground, in opposition to the force of gravity, — while the cohesion or contractility of a living muscle is about ten times that of a dead one, *ceteris paribus.** But I have shown that *this power depends on the rapidity with which the composition of the part is renewed by fresh arterial blood, and is in proportion to the amount of caloric that passes through it from the lungs in a given time.* For example, it is because more caloric is received from the atmosphere,

hydrogen, carbon, and nitrogen, so as to form the proximate constituents of organized bodies. But Liebig informs us, in his late excellent work on the Application of Organic Chemistry to Agriculture, that urea, allantoin, formic acid, and oxalic acid, which are products of vital action, have been formed out of the body by chemical action. I have shown, however, that the principal difference between the operations of ordinary chemistry and those of life is, that the latter are more complex. They are also more energetic and exalted in animals than in plants, because in the former the organizing principle is continually renewed. The truth is, that we cannot combine the elements of oxygen and hydrogen together, so as to form water, any more than we can form blood, or any other organized substance; but only bring the materials of which they are composed together, while nature performs the rest.

* The manner in which the contractile power of a muscle is maintained by the perpetual influx of arterial blood, and diminished by cutting off the supply, may be partially illustrated by the mechanical process of moistening a dry rope with water, which

and more blood generated in the lungs, of warm than of cold blooded animals, that the composition of the former is renewed more rapidly, their organization more highly developed, their powers of resisting the ordinary forces of chemistry much greater; and it is because the nutritive process is more rapid in birds than in mammalia, that the muscular power of the former so greatly exceeds that of the latter.

So long as any part of the body is supplied with good arterial blood, and with a copious flow of animal heat, by which its particles are united with the solids, and kept in a state of perpetual motion, chemical decomposition is prevented. But whenever the process of nutrition is greatly diminished, as in scurvy, typhus, yellow fever, and

causes it to contract with such force as to raise an immense weight from the ground, until the water is expended, when the weight descends. The reason of which is, that the particles of the rope have a stronger attraction for those of water than for each other without the intervention of a liquid. And such is the vast force with which water combines with dry wood, that by introducing dry wedges into the crevices of huge rocks, and keeping them moist, they may be readily split open. Humboldt, Cuvier, and some other physiologists, have maintained, that muscular contractility is generated by the perpetual coagulation of fibrin. And it must be confessed, that this explanation is a very near approximation to the truth; for it certainly does depend on the union of fibrin with the muscular tissue, during which it becomes solid, as in the process of coagulation. But they seem not to have had the slightest suspicion that caloric is the cause of both coagulation and nutrition; nor that the cohesive power of all the organs is diminished by its expenditure.

other malignant diseases termed putrid, chemical action commences, even before the entire extinction of vitality.* If then it be true, that *the vital force of animals, and their power of resisting the laws of dead matter, be in proportion to the quantity of caloric that passes through their tissues*, what shall we say of those physiologists who have written so many works on medical science, without even attempting to explain the office of heat in the economy of life, or what the blood receives while passing through the lungs, and what it loses while circulating through the ultimate tissues of the body ?

The wonderful activity and flow of spirits that characterize the period of youth, are owing to the rapidity of nutrition and growth. Like birds, children are in a state of perpetual motion during health ; and notwithstanding the smallness of their locomotive organs, many of them will run for hours without exhaustion. For the same rea-

* The extravasations of blood that take place during scurvy, the latter stages of typhus, and other malignant diseases, including the serous portion of the blood effused in dropsy, and which forms the rice water discharges of cholera, are owing to the broken down condition of the solids, and diminished cohesion of the capillary vessels, at a time when the nutritive process is nearly suspended. *The effusion of blood and serum into the ventricles of the brain in many cases of apoplexy is not the cause, but an effect of weakened cohesion of the vessels, which also constitutes the hemorrhagic and dropsical diatheses.* In cases of *chronic inflammation* of the brain and other organs, their texture becomes softened in proportion as the nutritive process is diminished.

son, the power of resisting the various causes of disease is greater during youth than at any other period of life; for it has been ascertained, that from the fifth to the sixteenth year, fewer deaths occur in England than at any other age. But after the completion of growth, or when nutrition and absorption become equal, all the functions of life are performed with less rapidity, while fatigue is much sooner induced by muscular exertion. And as old age comes on, the lungs diminish in volume, respiration, sanguification, circulation, secretion, nutrition, and all the operations of life become languid, the extremities cold, the skin dry and harsh, the hair grey or white, the muscles stiff, the eyes dim, the mind feeble, and "man hastens to his long home."*

In the theory of nutrition is to be sought the proximate cause of all diseases, from the simplest state of inflammation to general fever, consumption, dropsy, tetanus, and other spasmodic affections. For if the blood be the fountain of life, from which all the organs are immediately formed,

* In a fragment preserved by Philo, and ascribed to Hippocrates, the life of man is divided into seven ages; the first of which included the period of *infancy*, from birth to the end of seven years; the second, or that of *boyhood*, extended to the fourteenth year; that of *adolescence* to the twenty-first year; that of *youth* till twenty-eight, or full developement of the whole body; that of *perfect manhood* until forty-nine; that of *seniority* until fifty-six, when old age commences. (Opera Hippocratis, vol. i. p. 315. Vander Linden Edition.)

it follows, that whatever impairs its natural properties, must derange the nutritive process by which the healthy condition of the body is maintained. Nor is it possible that disease of the stomach, brain, or any other organ, could exist for any length of time, while supplied with an abundance of good arterial blood ; for if the latter be sound and healthy, so must be its products.

But if its natural condition be so far deranged, that its power of uniting with the solids, and of maintaining the various secretions, is seriously diminished, a portion of the caloric obtained by respiration, that is transferred to the solids during health, and expended in carrying on the various functions, is given out in the free state, or rather accumulates in the blood, causing a preternatural elevation of temperature, and loss of power in the general system. In other words, so long as the balmy vital warmth received in the lungs is employed in combining the proximate constituents of blood with the solids, and in elaborating the various secretions, the temperature of the body remains at the natural standard ; all the functions are performed with healthful regularity, and there is no preternatural or morbid accumulation of heat.* *Here then is a key to the whole theory of*

* Similar effects may be traced in the phenomena of nature on a grand scale. For example, so long as the caloric received from the sun is employed in combining with water, and converting it into vapour, which is carried off to colder regions by winds,

fever, which depends essentially on a diminution and derangement of the formative process, as shown by the rapid emaciation that takes place during its progress, and which always terminates on the restoration of secretion and nutrition.

The truth is, that all constitutional diseases are owing to some alteration of the blood, and derangement of its vital properties, which are impaired by whatever seriously diminishes the functions of respiration, secretion, and nutrition. If the capillaries of the lungs be paralyzed by the inspiration of cold air, less carbon and hydrogen than usual are given off, less animal heat evolved, the temperature of the blood is reduced, its due arterialization prevented, its healthy properties so far deranged, as to diminish its power of uniting with the solids, and of maintaining the various secretions. The consequence of which is, a congestion of blood in the lungs; and if the latter state remain for any length of time, there is a stagnation throughout the systemic capillaries, so long as the chill continues. During this state,

the atmosphere is kept at a moderate temperature, even during summer. But when the atmosphere is saturated with vapour, and its circulation ceases, as during the calm that precedes a thunder storm, *the earth becomes feverish*, (from an accumulation of caloric, which is no longer carried off in the combined state,) and oppressively sultry over large sandy plains, where there is no water. Besides, a large proportion of caloric is employed in the operations of universal chemistry, and the growth of vegetation, without which it would accumulate in the atmosphere in the free state, and render it oppressively warm.

the transition of caloric from blood to the solids is greatly diminished. But as the function of respiration, though greatly impaired, still continues to go on, the caloric thus evolved and imparted to the blood, gradually raises its temperature above the natural standard, by which the action of the heart is augmented, until the obstruction in the systemic capillaries is overcome, and the superfluous caloric is transferred to the solids, or carried off by the different emunctories, when the fever subsides.

If the blood be not constantly depurated by the elimination of sweat, urine, and other excrementitious matters, its vital properties are impaired, and the springs of life vitiated at the fountain head. For example, if there be 3lbs. of water exhaled from the skin every twenty-four hours, and perspiration be checked by exposure to cold, the chemical and vital character of the blood must be more or less changed, unless prevented by a copious flow of urine. Or if the amount of carbon and hydrogen exhaled from the lungs be greatly diminished, as during the cold stage of all maladies, the blood is no longer renovated as in health, but becomes grumous and dark coloured, and loses the power of uniting with the various tissues. It has also been found, that when the kidneys are extirpated, the animal is seized with difficult respiration, shivering, coma, fever, vomiting, purging, typhoid symp-

toms, and dies in from ten to thirty hours, or a few days at most, when urea is found in the blood. (Müller's Elements, p. 151.)

What then must be the result when nearly all the worn out or effete matter of the body, including the poisonous drugs so often introduced into it by physicians, are retained in the blood, as when the excretions are arrested? Has any thing noxious been absorbed into the blood through the lungs or from the stomach? it must be carried off by the emunctories before health can be restored. Nor is it possible to overcome any derangement of the solids, and bring the system back to its healthy state, without following the indications of nature by restoring the action of the emunctories, and thus improving the vital properties of the blood. Whenever circulation and nutrition are greatly diminished in any part of the body, its texture is very soon removed by the absorbents, causing an ulcer or abscess, which can be restored only by the formative process, or by the deposition of new matter termed granulations, that fill up the cavity. Has a bone been broken or attacked with necrosis? it can be united, and the loss repaired, only by the nutritive process. Or has the whole body been wasted by disease to a mere skeleton? it can be restored to its natural and healthy condition only by the same process.

The celebrated *vis conservatrix naturæ of Stahl, Gaubius, Mead, Cullen, and many other authors,*

is only a general term designating the natural action of all the organs; and is in proportion to the amount of respiration, sanguification, secretion, and nutrition. Hence it is, that a broken bone unites much sooner in birds than in mammalia, and sooner in all warm than in cold blooded animals, —sooner in youth and adolescence than in old age, and always sooner in persons of large chest and sanguine temperament, than in such as have a small thorax, imperfect lungs, or feeble and phlegmatic constitutions. But whenever the vital properties of the blood are impaired, and the formative process diminished, whether from disease of the lungs, the respiration of impure air, exposure to cold, over exertion of body or mind, im perfect nourishment, excessive medication, or the depressing emotions, the power of resisting the various causes of disease, (the *vis conservatrix naturæ*) of uniting wounds, and restoring lost parts, is proportionally reduced. *Nor is it possible that any general disease could exist so long as the blood is constantly renovated by respiration, and depurated* by excretion from the lungs, skin, kidneys, and bowels.

The circulation of arterial blood from the heart throughout all parts of the animal frame is somewhat analogous to the distribution of water from the ocean through the atmosphere by evaporation: and the return of the same water to the fountain whence it sprung, by innumerable rivers,

resembles the return of venous blood to the heart. The deposition of sedimentary rocks from a state of solution in the water of lakes and seas, is also somewhat analogous to the process of nutrition, by which the composition of animals is renewed ; while the removal of the effete portions of the body by absorption and elimination, is similar to the wearing away of mountains, hills, and elevated plains, by the corroding action of running water and chemical decomposition.

If then it be true, that the aggregate vital energy of animals and the development of their whole organization, are in proportion to the quantity of caloric they derive from the atmosphere by respiration, it must be the animating principle. Or if the faculty of sensation be annihilated by the abstraction of animal heat from the nervous system, it must be the sentient principle. And if the velocity of planets through their orbits diminish in proportion to their distance from the sun, it is self evident that their lasting motions would very soon come to an end, in the total absence of solar radiation. But as their centrifugal force is maintained by the perpetual radiation of caloric from the centre towards the circumference of the system, so is the centripetal force by which they are preserved in their respective orbits, maintained by the unceasing flow and pressure of the same great æthereal tide to the solar fountain from which it emanates.

Again, if it be true, as I have demonstrated, that the mobility and organizing power of matter are in proportion to the quantity of caloric around its atoms, and that these powers are diminished by every abstraction of caloric, or reduction of temperature; it follows, that in the total absence or privation of that principle, (if such a condition were possible,) the atoms of ponderable matter would be perfectly inert, and there could be no attraction, repulsion, contraction, and expansion of matter.

It was nobly said by Bacon, that "the highest ambition of man should be the discovery of some one thing by which all others might be discovered;" and that "science rightly interpreted, is the knowledge of things through their causes." Nor can there be a rational doubt, that a complete knowledge of the *prime mover* would afford a key by which to unloose the seals of the book of nature, and open the gates that lead to the inner temple of her most hidden mysteries. But owing to the paralyzing influence of custom, prejudice of education, and the dread of encountering the throned opinions of the world, few have had the boldness to inquire with unreserved freedom into the final cause of phenomena. The consequence of which has been, that the strength of many an intellectual giant has been wasted in fruitless efforts.

BOOK V.

CHAPTER I.

Influence of Climate and Season on the physical, intellectual, and moral Character of the Human Race, as shewn by the Difference of Stature, Magnitude of the Chest, Configuration of the Brain, Complexion, &c. among the Various Nations of the earth.

"If ever the science of life, and with it some of the most important departments of human knowledge, be destined to make any decided progress towards perfection, it must be by the road of experience, aided and enlightened by general philosophy."

LAWRENCE.

NEXT to the discovery and developement of some grand truth capable of universal application to the benefit of mankind, the most important service that an author could bestow upon his species, would be to select from the vast accumulation of fabulous and contradictory statements that compose the mass of our printed books, whatever is really valuable. For, at present, the elements of knowledge are scattered over so broad a field,—many of them are so imperfectly defined, and the truths already discovered are mingled with such a multitude of errors, that the best portion of

life is spent in learning how little is known with absolute certainty. But the time is not distant, when a unity and precision will be given to science, by a luminous arrangement of all its branches and their reduction to the simplicity of established principles, that will render its acquisition as delightful and rapid, compared with its former progress, as are the present means of locomotion by steam power, contrasted with the slow and laborious methods of travelling before that mighty engine of civilization was invented.

When it shall be fully understood, that the true method of exploring the head-springs of science, and of resolving the most difficult problems of nature, is to observe accurately, and record faithfully, all her proceedings, innumerable obscurities will vanish, like mists before the mid-day sun. And there is reason to believe that the partial success of philosophers has been owing to their having attempted too little rather than too much. For if it be true, that all the operations of nature are connected together as one harmonious system, it is obvious that no one of them can be rightly understood without a general acquaintance with the whole :—

> "The only hopes for ever doom'd to know
> A false event, are those that aim too low."

And if it be true, that caloric is the primary physical cause of all the mechanical, chemical, and vital changes of matter, it follows, that every di-

versity of organized bodies must be immediately connected with the agency of external temperature.

Perhaps there is not a greater contrast between the plants and animals of different planets, than between those of the tropical, middle, and polar latitudes of the earth. We have already seen, that the number of volcanoes, the elevation of mountains and plains, the amount of evaporation and rain, the magnitude of rivers, and the growth of vegetation, are in proportion to the heating power of the sun. Nor can there be a rational doubt, that if the earth were only a few millions of miles more or less distant from the sun, or that if the inclination of its axis were only a few degrees more or less than at present, all its chemical, geological, and physiological operations would exhibit corresponding variations.*

* As the law of gravity was first demonstrated by observing the revolutions of planets and their satellites, so will the great laws of physiology and pathology be discovered by means of accurate observations, extended over all parts of the earth, in regard to the influence of climate, geographical position, modes of living, civilization, forms of government, &c. on the physical organization and character, intellectual and moral, of the human race. It would be a great acquisition to our knowledge of the natural history of man, if all governments were to require annual returns of the marriages, births, stature, circumference of the chest, dimensions of the head, (from infancy to the completion of growth,) increase of population, diseases and mortality, of all their inhabitants. May we not hope that philosophers will use their best exertions to bring about so desirable an object.

For the sake of convenient reference, I shall regard the earth as divided into five zones or isothermal bands, each of which presents a different climate. For example, whenever the mean annual temperature is 80° or upwards, and summer perpetual, the climate is *hot* or *tropical.* According to Humboldt, the mean of the year varies from 80° to 60°, between lat. 30° in North Africa, and 43° in Europe; and from lat. 23½° to about 33° N. in Asia and America. In this zone, summer greatly predominates over all the other seasons, and the climate may be denominated *warm.* But in the middle latitudes, where the duration of summer, autumn, winter, and spring, is nearly equal, and the mean temperature of the year varies from 60° to 50°, as in the greater part of Europe, northern Persia, China, and most of the United States, the climate should be designated as *temperate.* Where the mean of the year ranges from 50° to 40°, and winter predominates over any of the other seasons, as in central Asia, Russia, Norway, Sweden, Denmark, and Poland, in Europe; and Canada, Nova Scotia, New Brunswick, and the northern portions of the United States in America; the climate should be distinguished as *cold.* But in all the desolate regions beyond, in which the mean annual temperature varies from 40° to 32°, or even 0°; and where winter continues from nine to ten, and even eleven months in a few places, the climate should be termed *frigid.*

How striking is the contrast between the botanical and zoological character of these different zones. The first abounds with palms, bananas, sugar, coffee, myrtles, pomegranates, and aromatic spices; the second, with oranges, limes, figs, maize, rice, olives, grapes, and other delicious fruits: while the third is the favourite region of the grasses, wheat, barley, rye, oats, and a variety of forest trees, not found in tropical and warm climates,—nor in the regions of perpetual cold, where only a few species of low cryptogamous plants are produced. In accordance with the foregoing facts, it has been shown by Humboldt, that the strength and continuance of vegetation are in proportion as the temperature rises above 52°, below which, it is arrested in all climates; and that the number of vegetable species in the tropical, temperate, and polar latitudes, is in the ratio of 12, 4, and 1; so that *the growth of vegetation may be regarded as a natural thermometer on a grand scale.*

But as all animals are nourished by plants, or by animals that have lived on plants, it is clear that the capacity of any country to support a numerous and wealthy population, must depend chiefly on climate. For example, throughout the whole of Asia and North America, above latitude 50°, the mean annual temperature is below 52°, and the growth of vegetation is arrested for ten or eleven months in the year, while in the coldest

places (which are the foci of magnetic power,) it falls 60° and 70° below 0° during winter.* The consequence of which is, that in the vast regions of Siberia, embracing an area of 4,010,000 square miles, the number of inhabitants does not exceed 3,600,000 who, from the nature of the climate, are compelled to obtain a miserable subsistence by fishing and hunting.

In the still more desolate regions of British and Russian America, on a territory of 3,650,000 square miles, the native population does not exceed 200,000, who live mostly in snow huts,

* This extreme coldness is owing to the large amount of dry land in the polar regions. And as it is three times greater in arctic America than Asia, according to Humboldt, the former is colder in the same parallels. For as the warming influence of the sun does not extend above two or three feet below the land surface in the polar latitudes, they are very soon cooled down by radiation in winter. But as bodies of deep water are warmed for several hundred feet during summer, they continue to give out caloric to the superincumbent atmosphere during winter, until reduced to the freezing point, when they present the character of a continental climate. It is therefore manifest, that if the space now occupied by land, above the latitude of 60°, were replaced by an ocean, the temperature of the whole northern hemisphere would be greatly moderated. For example, owing to the prevalence of west winds from the Pacific Ocean, the mean annual temperature of New Archangel in latitude 57° N. on the western coast of America, is 45·2°, but only 26°, on the eastern coast of Labrador in the same latitude. The western coast of Europe is also several degrees warmer than the east, on account of the prevalent west winds from the Atlantic. For example, Moscow has a much colder winter in latitude 55°45′, than St. Petersburgh, in latitude 60°.

clothed with skins, and nourished by animals, obtained chiefly from the sea. Without agriculture, commerce, manufactures, or the possibility of uniting together under regular forms of government, they are reduced to a state of complete barbarism ; and, like the scattered tribes of northern Asia, are mere dwarfs in stature as in mind.

And if we pass to the elevated plains of ancient Scythia, in central Asia, where the climate is colder than any part of the northern hemisphere in the same latitudes,* where bleak northerly

* Central Asia is bounded on the north by the Altai mountains, which extend from west to east across the continent,—on the south by the great Himalaya range, which extends from the north of India eastward, across China, and westward until it takes the name of Hindoo Koo, and Caucasus, the ancient name of that vast range, on some part of which Prometheus is said to have been bound for stealing fire from heaven. Between these two great mountain chains there is another lofty range termed the Thian Chan mountains; so that a large portion of the country is from eight to ten thousand feet above the sea, and nearly the whole of Tartary about five thousand feet. But another cause of its extreme coldness and dryness is, that the warm winds which blow during summer from the Indian Ocean, are prevented by the lofty Himalayas from passing over the plains of the interior, and deposit nearly all their vapours in floods of rain, on the southern portions of the continent. In addition to this, the prevalent west winds from the middle latitudes of the Atlantic give out a large portion of their caloric, and deposit nearly all their moisture while passing over Europe, and before arriving at central Asia, becoming cold and dry as they advance eastward. Hence it is that the mean temperature of winter at Edinburgh in lat. 55°57′ is 38·6°, while at Moscow in the same latitude, it is only 10·8°, and about the same in Circassia, 10° further south.

winds prevail for eight or nine months in the year, the growth of vegetation is always imperfect; and according to Balbi, on a territory of 4,250,000 square miles, the number of the inhabitants does not exceed 30,000,000, who for the most part lead a wandering or nomadic life, and have never made any considerable progress in civilization, science, literature, and the arts, if we except the brutal art of war; so that if we include the whole of North America above latitude 50°, and of Asia above 40°, the population is only about 33,800,000, on a territory of nearly 12,000,000 square miles.

But in the warm and temperate latitudes of Asia, south of latitude 40°, where the growth of vegetation continues from six months, as in the north of China, to ten months, and even the whole year, in the southern portions of the continent, the population is about 400,000,000, on a territory of 6,450,000 square miles. In India, it is 140,000,000 on an area of 1,200,000 square miles; while in China alone, between latitude 20° and 40°, it is about 200,000,000, making an aggregate of 340,000,000 on a territory of 2,840,000 square miles. From which it may be shown by calculation, that if the climate of northern Asia and America were equally favourable, they might support a population of more than 1,400,000,000 on a territory of 12,000,000 square miles; whereas it is only 33,800,000. And what is their rank in the scale of intellectual and moral enjoyment?

If we pass to the warm and temperate latitudes of Europe, where the growth of vegetation continues from six to ten months in the year, and the inhabitants are seldom pinched with extreme cold, or exhausted by excessive heat, the population is about 170,000,000, on a territory of 1,425,000 square miles. In the United States, the climate and soil of which are equally genial and fruitful, there is a territory of 2,300,000 square miles, with a population of 17,000,000; which, should it go on doubling every thirty-six years, will be 150,000,000 in another century. And if the period of doubling be then fifty years, it will be 600,000,000 in another century.* Nor can there be a reasonable doubt, that improvements in science, agriculture, the arts, and the adoption of a chiefly vegetable diet, will afford the means of supporting in comfort a much greater population to the square mile, than has ever yet existed

* But if a lofty chain of mountains extended north westward across the continent from lat. 24° to 45°, like the Himalayas in Asia, it is evident that the middle and northern states would have a climate resembling that of ancient Scythia; and that their future history would be proportionally modified. As the sovereign of the earth, man has the power of removing forests, draining marshes, dyking rivers, and of improving his condition in an endless variety of ways. But he cannot alter the mean temperature of the earth, nor any considerable portion of it, the thousandth part of a degree, any more than he can prevent the elevation of mountains, the direction of winds, or the revolutions of planets. In the city of London, with its 400,000 fires, the mean of the year is but 2° higher than in the surrounding country.

in any part of the world. And should the colonies of Great Britain, now pouring into many of the best portions of the earth, continue to multiply as at present, the language, civilization, intelligence, wealth, and growing prosperity of the Anglo-Saxons must ultimately prevail in every quarter of the habitable globe.

In the north of Europe, including Russia, Sweden, Norway, Denmark, and Poland, where the mean annual temperature of the year varies from 38° to 45°; and where the growth of vegetation is arrested from eight to nine months in the year; the population is only about 65,000,000 on a territory of 2,074,000 square miles. Owing to the severity of the climate, there is a deficiency of grass and grain for domestic animals; while the demand for fuel, clothing, and warm houses, requires a corresponding amount of labour; all of which diminish the resources of the people, and retard the progress of civilization, literature, science, and the fine arts. Corresponding with these facts, we are informed by Balbi, that the revenues of Great Britain, independent of her colonies, are nearly three times greater than those of all the nations in the north of Europe.

Nor is it less certain, that excessively hot climates are unfavourable to the population, wealth, civilization, refinement, and general prosperity of nations. For although the tropical zone abounds with delicious fruits and other aliments,

it is deluged with rains for six months, attended with dreadful hurricanes; and parched with drought during the remainder of the year:* while the frequency of earthquakes and volcanic eruptions cause the overthrow of many cities, and the destruction of many thousand lives, not to mention the pestilential character of the atmosphere. Such is the deleterious influence of the torrid zone on the growth of population, that in the vast continent of Africa, it does not exceed 57,000,000; or if we take the estimate of Balbi, 60,000,000, on a territory of 11,000,000 square miles, a large proportion of which is found above north lat. 30°, where the mean temperature of the year varies from 78° to 68°, and where considerable advances have been made in wealth, civilization, arts, science, and social improvements; as

* The reason of which is, that when the sun is south of the equator, there is a perpetual under current of air from the higher and cold latitudes of the northern hemisphere to the tropical zone; where being expanded, it rises loaded with vapour, and flows back as an upper current before the tropical atmosphere becomes saturated, or precipitation takes place, causing a drought of six months on this side of the equator. But when the sun returns to the northern hemisphere, the land becomes so heated, even in the higher latitudes, that the under current from the north is greatly diminished, and nearly ceases within the northern tropic. The consequence of which is, that the vapour carried into the atmosphere, instead of passing with an upper current to the higher latitudes, accumulates within the tropics, and is almost daily precipitated in floods of rain, attended with frightful explosions of lightning and peals of thunder.

in ancient Egypt, Carthage, and other Phœnician states.

Owing to there being a much larger body of dry land exposed to the influence of a tropical sun in Africa, than in any other part of the world, it has a higher temperature during the hottest part of the day. For it has been shown by Humboldt, that the heat of any country is in proportion to the extent of fixed surface between lat. 40° on each side of the equator, modified by elevated mountains, plains, forests, and sandy deserts. For example, tropical Africa is hotter north than south of the equator; first, because it is broader north of the equator, from which it narrows on to the Cape of Good Hope;* and secondly, because

* If southern Asia extended over the space now occupied by the Indian ocean, as far as 30° S. interspersed with large sandy deserts, the temperature of tropical India would correspond with that of central Africa, and the whole continent would be considerably warmer than at present. Or if instead of narrowing from the United States, on to the isthmus of Darien, North America extended over the space now occupied by the Atlantic as far as the equator, with a breadth of 4000 miles, its climate would have corresponded very nearly with that of Africa in the same latitudes. But as Africa and Asia contain five or six times more dry land between the latitudes of 40° on each side the Equator, they are warmer, especially Africa, than America in the same parallels. It may also be worthy of notice, that the western coast of tropical Africa is hotter than the eastern coast, which is somewhat cooled by the trade wind, which also moderates the temperature of tropical South America on the east. In the same way, the temperature of Southern Asia is moderated by the monsoons which blow from the Indian ocean during summer.

of the great desert of Sahara, which extends from lat. 15° to 30° N. and from the Atlantic ocean to Egypt, over an area of 300,000, square miles,—with no mountains, and scarcely any rain, to mitigate the influence of the blazing sun.

The consequence is, that in Soudan, Bennin, Dahomy, Coomassie, Ashantee, and other portions of tropical Africa, the temperature rises to 108° and sometimes to 113° in the shade, during the heat of the day, according to Denham, Clapperton, and other travellers. It also rises to 112° in the hottest parts of New Holland, as we are informed by Mr. Lang—owing to the absence of mountains, the scarcity of rain, and the prevalence of sandy deserts. Corresponding with this state of things, the native population of New Holland does not exceed 500,000 savage negroes, on a territory of 3,000,000, square miles, which is nearly equal to that of all Europe.

Thus it is, that no great, wealthy, populous, and highly civilized nation, has ever existed in either excessively hot or cold climates. If man be dwarfed in stature, and all his higher faculties blunted, by the torpifying agency of intense and long continued frost—he is equally degraded by the perpetual influence of an elevated temperature, which blackens his skin, renders his hair coarse, harsh, and curly, while it impairs the vigour and beauty of his whole organization. For example, the head of the negro is not only smaller in every

direction than that of any other race or nation, but the greater part of the brain lies behind a perpendicular line drawn from the *meatus auditorius externus.* The skull is thick and heavy, but narrow or compressed at the sides, the forehead low and retreating, the cheek bones prominent, the jaws strong, the mouth large, the lips thick and gross, the nose flat, the nostrils wide, and the chin small. The fore-arm is longer compared with the humerus than among other nations, the fingers long, slender, and sinewy, with nails like claws. Like the lower animals, the thigh is longer compared with the leg, thinner from side to side, and deeper from front to rear, than among the whites, or the tawny coloured tribes. The *os calcis* projects backwards, the foot is flat, and the leg slender, presenting the appearance of a mattock with its handle; while the toes are long and slender, with strong crooked nails that resemble claws. Such is the outline of the negro, as described by Blumenbach, Prichard, Lawrence, Caldwell, and other writers on the natural history of man. It is therefore not surprizing that for thousands of years, the natives of central Africa have remained in a state of the grossest barbarism,—nor that they have been reduced to slavery by the Egyptians, Phœnicians, Persians, Greeks, Romans, and nearly all the nations of modern Europe.

It is certainly true, that some of the most

populous, wealthy, and highly civilized nations of antiquity, flourished in southern Asia and northern Africa; as in India, China, Arabia, Syria, Egypt, Tyre, Sidon, and Carthage. But the climate of these countries is moderate, compared with that of tropical Africa and New Holland; or intermediate between what I have denominated hot and temperate climates. For example, the mean annual temperature is 70° at Algiers; in winter it is 61·4° and 82·8° in summer; while at Cairo in Egypt, the mean of the year is 72·4°, that of winter 58·4°, and that of summer 85·8°. Corresponding with this intermediate climate, is the physical character of the natives, who are neither black nor white, but dark brown, olive, or yellow; with long and slightly curled hair, regular features, sparkling eyes, slight but muscular frames, well formed heads, and a considerable share of intelligence.

Yet among all the monuments of southern Asia and northern Africa, there is nothing in architecture, sculpture, poetry, painting, &c. equal to the finest models of Greece. And there is reason to believe, that in the still more uniform climate of Great Britain, where the grass is rarely killed by frost, or parched with excessive heat, but remains green throughout the year, man has arrived at greater size, strength, and longevity, including all the endowments of a vigorous physical, intellectual, and moral organi-

zation, than in any other part of the world: for it produced Bacon, Shakspeare, Milton, Chatham, and Watt, who have surpassed all the poets, philosophers, orators, and inventors of antiquity. The population of a small island has acquired more wealth and power than was ever possessed by any other nation; and has done proportionally more towards the diffusion of useful knowledge throughout the civilized world. We are also indebted to Germany, whose climate is nearly the same as that of Britain and France, for the noble invention of printing, the great discoveries of Copernicus, Kepler, and Humboldt, who was the greatest naturalist of the nineteenth century.

It has been said that "there is nothing more difficult to explain fully, than the immense superiority of Europe over the other quarters of the world." But I shall endeavour to show that it is, because the climate of middle and southern Europe is more temperate and uniform. In the first place, there is nothing better established by history, than the superiority of man in temperate latitudes. The once populous and wealthy nations of Egypt and Syria were conquered by the Persians, Medes, Greeks, and Romans,—the Chinese by the Tartars,—Italy by the Germans, Goths, and Huns,—northern Africa by the Romans,—and the East Indies by the British, who are now invading China.

In the middle latitudes of Europe, the mean temperature of winter varies from 38° to 40°, and that of summer from 58° to 66°; while in the south of Europe, it is from 45° to 52° in winter, and from 70° to 75° in summer. The mean difference, therefore, between winter and summer, varies from about 20° to 25°; and the average of the year is from about 50° to 60°, while the annual extremes are from about 10° in winter, to 85° or 90° in summer. In the north of Europe between lat. 50° and 60°. the mean annual temperature varies from 50° to 38°,—that of winter from 30° to to 10°, and that of summer from 62° to 69°;—so that between the mean of winter and summer, the difference is from 39° to 52°, while the annual extremes are from 120° to 130°.

In the United States, the mean temperature of the year between lat. 48° and 30°, is nearly the same as in Europe between lat. 35° and 60°;* and varies from about 40° in the north, to 60° and upwards in the south. But owing to the greater amount of dry land in polar America, and the absence of an ocean wind from the west, the extremes of temperature are much greater east of

* Owing to the prevalence of winds from the Atlantic during the greater part of the year, the west of Europe has a maritime climate, and a higher mean temperature than Asia or America, in the same latitudes. But as Humboldt observes, this is owing in part to the heating influence of Africa, from which Europe is separated on the south only by the Mediterranean; and partly to the small amount of land in the polar latitudes.

the rocky mountains, than in the same latitudes of Europe. For example, in the Canadas, Nova Scotia, New Brunswick, and the states north of 42°, the mean of winter varies from 14° to 34°, and sometimes falls 30° or 40° below 0° during the coldest days; while the mean of summer is from 64° to 70°, and often rises to 95°, or even 100° in the shade, during the heat of the day,—making the mean difference between winter and summer from 50° to 36°, and the annual extremes from 130° to 140°.

But in the middle states between 42° and 36°, where the mean of the year varies from near 60° to 50°, that of winter is from 35° to 27°, of summer 76° to 72°, making the difference from 45° to 41°, and nearly double what it is in the middle and southern latitudes of Europe, where the annual extremes rarely exceed 90°, whereas in the middle United States, they vary from 100° to 120°. In the southern states, the mean temperature varies from about 60° to 70°, while that of winter is from near 40° to 50°, and the number of growing months from seven to ten. In the middle states, they are from six to seven, and above latitude 42°, from four to five. As for the rest, the extremes of temperature diminish as we proceed from north to south in all climates of the northern hemisphere, *ceteris paribus*.

At Pekin in the north of China, and lat. 39°, 54′, corresponding very nearly with the parallel of Philadelphia and Cincinnati, the mean tempera-

ture of the year is nearly the same, or 55·2°. But that of winter is 26·8°, and that of summer 82·6°, making a difference of nearly 56°, which is 21° higher than in the same isothermal zone of Europe; 11° higher than in the middle states of America, and greater than in Russia, Nova Scotia, or Canada. Owing to its exposure to the bleak winds of Tartary, and the hot winds from the south, the climate of northern China approximates that of the polar regions during winter, and that of the tropics during summer. The truth is, that scarcely any part of Asia possesses what may be called a temperate climate, if we except that portion termed Asia Minor, which lies between the Mediterranean and the Black Sea. For in the regions south of the Himalayas, there are but two well marked seasons, the dry and the rainy; while in the vast plains beyond that immense chain of mountains, and from the Caspian to the Pacific, the only seasons are a long and rigorous winter, followed by a brief, dry, and unfruitful summer.

But in the temperate latitudes of Europe between 35° and 55° north, there is a delightful succession of winter, spring, summer and autumn, with frequent alternations of sunshine and gentle showers, without floods of rain, desolating hurricanes, and long droughts. The same observations apply to the United States south of latitude 42°, where the temperature is never tropical during

summer, if we except a few weeks, nor polar in winter, beyond a few days, and but seldom. Throughout the greater part of that beautiful and fertile country, the climate is strictly temperate, and far better adapted to the support of a numerous, wealthy, and highly civilized population, than that of China, India, Persia, or any other portion of Asia.

Let us now examine how far, and in what way, the stature, strength, form of the body, size and configuration of the head, are modified by climate or external temperature. In the first place, then, it would seem to be a law of nature, *that in man and all the higher animals, respiration is augmented in proportion as the surrounding temperature falls below the point at which they are capable of maintaining themselves at the natural standard, but diminished in proportion as the atmosphere rises above that point, ceteris paribus.*

For example, it was ascertained by Dr. Crawford, that when a guinea pig was taken from the air of a room at the temperature of 61° and confined in air surrounded with water at $55\frac{1}{2}°$ for forty-two minutes, it expired double the amount of carbonic acid as when kept in air at 104° for the same time. In another experiment he found that on surrounding a guinea pig with air at 36°, it generated three times more carbonic acid in the same time, than when made to breathe air at 102°

F.* (Experiments and Observations on Animal Heat, pp. 311, 387.)

Now if these experiments are to be relied on, and the first of them be taken as a standard, it follows that respiration is diminished 100 per cent. by elevating the temperature of the air 48°, which is the difference between 55° (omitting fractions)

* In the Memoirs of the French Academy of Sciences for 1789 are recorded some experiments performed by Lavoisier on M. Seguin, a vigorous young man, who consumed 1344 cubic inches of oxygen per hour, when surrounded with air at 59°, and 1210 cubic inches, when supplied with air at 91°. From which it would appear that respiration was diminished only 10 per cent. by elevating the surrounding air 32°, or from 59° to 91°, which is about the difference between the temperature of London or Paris, and that of the tropics. It also follows from these results, that the average amount of respiration is only 25·62 per cent. greater in polar America than within the tropics, and 62·5 per cent. more at 70° below 0°, than at 130°, as when exposed to an African sun. And as the density or sp. gr. of elastic fluids is diminished 100 per cent. by 480° of heat, (see p. 103,) it follows that the same volume of oxygen would weigh 6·66 per cent. more at 50°, (the mean temperature of London) than at 82°; and 17 per cent. more at 0°. Corresponding with these facts, it has been observed by the manufacturers of iron in Europe and the United States, that more caloric is obtained by ordinary combustion during winter than summer, especially when the air is sultry and saturated with vapour, which carries off a large amount of caloric in a combined or latent state; and that a larger amount of fuel is required to perform the same duty, than when the air is cold and dry. It is not true, however, that sun shine puts out a common fire, as the vulgar suppose, but it is rendered invisible or obscure by the superior lustre of the sun. Yet Dr. M'Keever found that in a dark room at 63°, one inch of a common candle was consumed in fifty-six minutes, but required fifty-nine minutes in strong sun shine at 80°.

and 104°, without taking into account the hydrogen that unites with oxygen in the lungs. It would also follow, that in the polar regions, where the mean temperature is at 0°, 104 per cent. more caloric is obtained by respiration than in the middle latitudes where the air is at 50°—170 per cent. more than within the tropics where the annual average is 82°,—375 per cent. more during winter in the polar regions, where the temperature is 70° below 0°, than where it is at 110°, as in central Africa,—and 416, per cent. more than at 130°, as when exposed to a tropical sun. But if we take the mean results of Crawford and Lavoisier, it may be found by an easy calculation, that 38 per cent. more oxygen is consumed at 50° than at 82°, —97 per cent. more at 0°,—215 per cent. more at 70°, below 0° than at 110°,—and nearly 240 per cent. more than at 130°.

Again, as I have shown it to be a law of nature, that the aggregate forces of life in animals are in proportion to the amount of caloric that passes through their tissues in a given time, it might be supposed, that they are more energetic in the polar regions than in temperate, warm, and tropical climates. But notwithstanding the large amount of caloric obtained by respiration, it is still more rapidly abstracted by the surrounding air, in excessively cold climates, and before it has time to perform fully, its life-giving office of nourishing the solids. Hence it is, that the

average height of the Tartars* on the eastern coast of Asia, does not exceed five feet three inches English, according to the measurements of M. Rollin, who accompanied the expedition of Perouse; while it is known that in the frozen regions of Siberia, Lapland, British America, and Terra del Fuego, the natives vary from four and a half to five feet in stature, with remarkably small hands and feet, as if their growth were stinted by exposure to extreme cold. And although the head is sometimes large, the perceptive, intellectual, and moral organs, are imperfectly developed, as shewn by the smallness of the superciliary ridges, lowness of the forehead, and flatness of the coronal region,—corresponding with their want of sensibility, the more refined emotions of love, and all the higher endowments of genius. They are also exceedingly ugly and ill formed. The skin is rough and thick, the hair straight and coarse, the beard scanty, the face broad and flat, the nose short, the eyes narrow and oblique, the cheek bones prominent, the mouth and ears large.

The thorax is also much larger in proportion to the whole body, among the Esquimaux, Samoiedes, Yakouts, Tungouses, Finlanders, Laplanders, and even the Tartars of central Asia, than

* And Pallas informs us, that the Mongolian Tartars generally, are greatly inferior in muscular strength to the Russians, who are inferior to the British and Germans.

among the nations of temperate climates, as we learn from Pallas, Forster, Hearne, and other travellers, who represent the chest and shoulders as so broad as to give the appearance of deformity. This peculiar conformation of the thorax in excessively cold climates, is doubtless owing to the continual necessity of exercising the lungs, by which their development is augmented, for the purpose of compensating the rapid loss of animal heat. For whenever caloric is abstracted from the body faster than it is supplied by respiration, a painful sensation of chilliness is produced, which, like the cold bath, prompts the individual to take more full and frequent inspirations.

Moreover, owing to the large demand for fuel to support combustion in the lungs, the inhabitants of the frozen zone require a corresponding amount of animal and oily food, of which an Esquimaux devours from ten to twenty pounds a day,* according to Sir John Ross; who says, "the *true secret of preserving life, in the polar regions, is a large use of fat meats.*" (Narrative, p. 200—448, 1835.) And Sir John Franklin observes, that " during the whole of our march, we experienced that no quantity of clothing would keep

* But this would be impossible, or at least extremely injurious, if not fatal, to the inhabitants of tropical and warm climates, in which the natives require less food than in the higher latitudes, and where they prefer vegetable to animal food, which affords less carbon and hydrogen, therefore less caloric by respiration, than animal nourishment.

us warm while we fasted; but if enabled to go to bed with full stomachs, we passed the night in a warm and comfortable manner." (Journey to the Polar Sea, in 1819—22, p. 447.) We are also informed by Claridge, that at Gräefenberg in Germany, where the celebrated quack Priesnitz subjects his patients to the cold bath, from fifteen minutes to an hour, three times a day, and makes them drink from ten to twenty glasses of cold water in the same time, for the cure of all diseases,—they consume an enormous amount of animal food and pastry,—that "the water cure gives an appetite, and forces the invalid to eat more than he was accustomed to in health."* (Hydropathy, p. 254.)

On the other hand, in the tropical portions of India, Africa, America, and New Holland, the thorax is narrow, flat, and its circumference considerably less than in the higer latitudes, according to the best information I have been able to obtain from writers on the Natural History of Man. The reason of which is, that whenever the temperature of the atmosphere rises above the point

* It is therefore manifest, that men require a more abundant supply of animal or oily food when exposed to intense cold, and are badly clothed, than when protected by warm houses and garments. Nor could the patients of Priesnitz obtain a sufficiency of animal heat by respiration to keep them alive under his cruel practice, without an abundant supply of oleaginous food, or such as abounds with carbon and hydrogen, as will be further shown when I come to treat of aliments.

at which the body is capable of maintaining itself at the natural standard, the caloric obtained by respiration is not carried off, as at lower temperatures, but accumulates in the system, producing a disagreeable sensation of preternatural warmth, the tendency of which is to diminish the action of the lungs, and the generation of caloric. By means of this admirable instinct, founded in the natural aversion to pain, whether from excessive heat or cold, men and other animals are prompted to accommodate the amount of respiration to the wants of the system, in different climates and seasons.

But it is not only respiration that is from 30 to 38 per cent. less in tropical than in warm and temperate climates, like those of Greece and Italy, France and England; for I have proved that secretion, nutrition, or the formative process by which the composition and vitality of the body are maintained, depend on the transition of caloric from arterial blood to the solids. It is therefore evident that the aggregate forces of life must be diminished in proportion as the temperature of the solids approximates that of the arterial blood.*

* But as in the hottest climates the atmosphere is seldom above the natural temperature of birds, it is obvious that in them the process of nutrition, and the general powers of life, are much less impaired than in the active mammalia; and less in most of the latter, such as the dog, wolf, fox, sheep, ox, horse, deer, hog, &c. than in man, whose average temperature is several degrees lower. Hence it is, that warm and hot climates are more favourable to

Hence the dibilitating influence of the hot bath when continued for any considerable time. But what else is the burning atmosphere of tropical climates than a heated air bath? And hence the invigorating influence of the tepid bath in such climates, or even of the cold bath, when employed for a short time, as it then augments respiration. It is also of still greater importance in all cases of preternatural or febrile temperature, by reducing the solids to the natural standard, so as to favour the nutritive process, which cannot be carried on without the transition of caloric and arterial blood to the solids. Nor is it possible, that fever or any other constitutional malady can exist, so long as this process is carried on in the natural manner,—or so long as the blood is constantly renovated in the lungs, and depurated by excretion. But the employment of cold must never be carried so far as to reduce the system below the normal standard, as it then dimi-

the growth, strength, and health of birds, than to mammalia, if we except the monkey tribes, the elephant, camel, rhinoceros, lion, tiger, leopard, and a few other species, whose lungs are not sufficiently developed to maintain their temperature during winter in the higher latitudes, without artificial warmth. Nor could man exist in cold climates without the aid of fires, or plenty of food and warm clothing. Sir Charles Morgan observes, that in such climates, "the whole energy of life is expended in maintaining temperature." (Philosophy of Life, pp. 434.) He might have said that heat is so rapidly abstracted as greatly to diminish the powers of life, which are very soon annihilated without a due supply of that important agent.

nishes the power of the heart, the circulation of blood through the lungs, and therefore the process of respiration, on which all the other functions of the animal economy depend,—for the same reason that all the movements of the atmosphere, evaporation and rain, the operations of chemistry, geology, and the growth of plants, depend on the heating influence of the sun.

Some experiments of Dr. Edwards clearly prove that, like mammalia, birds obtain more caloric by respiration during winter than summer. For he found, that when five adult sparrows were placed in a vessel through which there was a free circulation of air, (with a solution of pure potass to absorb the carbonic acid exhaled,) they lost only ·72° of temperature in one hour, in the month of February, when the air was at 32°. But when the same species of birds were placed in air reduced to 32° in summer, by means of a freezing mixture, they lost from 6·5° to 10·8° in one hour, and 21·6° in three hours.*

* Yet he maintains, in a recent article on Animal Heat, contained in the Cyclopedia of Anatomy and Physiology, that *respiration is augmented by the high temperature of tropical climates*, and the heat of the body increased until the condition becomes pathological, as in fever. (Vol. ii. p. 679.) He adds in another place, that as the proportion of red globules in the blood, exerts an important influence on the generation of heat, that of fever may be reduced by bleeding and low diet. Dr. C. Holland also maintains that the effect of a high temperature is to produce a more oxygenated state of the sanguineous fluid,—which he thinks predis-

When the lungs have become adapted to the temperature of summer, they do not suddenly accommodate their action to that of freezing water. Hence it is, that all rapid transitions from heat to cold, and from cold to heat, are unfavourable to health ;—that when the natives of the higher latitudes are removed to hot climates, they generate caloric by respiration faster than it is carried off, and are therefore liable to fever, which should be prevented by a cooling diet of fruits and vegetables, frequent cold ablutions, or by bathing in cold water seven times a day, if necessary, until the body is reduced to the natural standard, or to the point of actual comfort. On the other hand, when the natives of hot climates are removed to the higher latitudes—owing to the smallness of their lungs, they do not obtain caloric by respiration so rapidly as it is wasted,—which renders them liable to diseases of the lungs, rheumatism, and other inflammatory affections.

Corresponding with what has been said of the

poses to fever and other tropical diseases. (Laws of Organic Life, and Principles of Medicine.) From which it would appear, that both of these intelligent physiologists imagine, that an increase of respiration and generation of animal heat are essential to the existence of fever. But I have proved that the proportion of red globules in the blood depends on the amount of respiration, which is always diminished by an elevated temperature. Nor does fever depend on the quantity of caloric obtained by respiration, but on a deranged condition of the blood, by which it is prevented from passing to, and combining with, the solids.

diminished respiration in hot climates, the natives of central Africa, (including the great Desert of Sahara) New Holland, New Guinea, Sumatra, and Borneo, are greatly inferior in stature, muscular strength, size and configuration of the brain, beauty of features, intellectual and moral endowments, to the inhabitants of temperate and warm climates. For example, Mr. Lawrence found the average height of five negroes, who were descended from native Africans, to be five feet six inches. And it is stated in the Phrenological Journal, by the surgeon of the ship Blossom, commanded by Captain Beechy, that the general height of the negroes brought from tropical Africa to Rio Janeiro, was about five feet five inches. (Vol. iv. p. 624.)

Nor is it less certain, that the Affghans of northern India are a large, athletic, and powerful race, compared with the tropical Hindoos, who, although evidently belonging to the same original stock, do not exceed five feet six inches in height. The same difference exists between the northern and southern Chinese,—the natives of Persia, Turkey, Georgia, Circassia,—and the Arabs of southern Asia and northern Africa, including the Egyptians. The Patagonians, the Araucoans of Chili, and other tribes that inhabit the temperate latitudes of South America, like the North American Indians in corresponding latitudes, are also much larger, stronger, and

more courageous, than those of Brazil, Paraguay, Mexico, and Peru, who like the Eboes, Gaboons, Mandingoes, and other blacks of tropical Africa, New Holland, and New Guinea, have always been a feeble, indolent, and servile race. As we advance from the middle latitudes of America to Cape Horn southward, or to the Arctic Ocean northward, man diminishes in stature until the average does not exceed four and a half or five feet.*

There is nothing in the history of our race more certain, than that in all the attributes of a vigorous and beautiful organization, man has attained to the highest perfection in the temperate zone. How striking is the contrast between the tall European, with his high and expanded forehead, large, bright, and intelligent eyes, oval face, and well marked features, compared with the low thick stature of the northern Asiatic, or the native of polar America, with his square head, flat face,

* The horse, ox, deer, sheep, goat, dog, and some other domestic animals, are also larger, better formed, and more vigorous, in the middle latitudes, than in either the tropical or polar regions. And although the elephant, rhinoceros, hippopotamus, giraffe, lion, tiger, and some other mammalia, attain to very great size within the tropics, they have less strength and activity than animals in the middle latitudes of the same size.

And if reptiles are larger in hot than in cold climates, it is because their respiration is imperfect, and arrested for six or eight months in the higher latitudes, during which they cease to grow; whereas within the tropics, they continue to grow throughout the year.

large cheek-bones, low forehead, broad nose, small eyes, and ill defined features; or with the black skin, coarse woolly hair, large mouth, thick lips, broad flat nose, advancing jaws, diminutive forehead, and dull eyes, of the African! the Berbers of north Africa, like the Caffres of the south, are also greatly superior in strength, activity, symmetry of form, regularity of features, and intelligence, to the tribes of the interior, who are distinguished by low cunning, cruelty, cowardice, and sensuality.

The climate most favourable to a high development of the human race, would seem to be one in which the mean annual temperature approximates that of the whole earth, which is about 50°, and in which the variations are small, as in the middle latitudes of Europe, where the average of summer is seldom more than 10° above the mean of the year, and that of winter rarely more than 10° below the same standard. For man has attained to larger stature in Great Britain, Germany, Holland, Belgium, Prussia, Sweden, and Russia, than in any other quarter of the world. It was long supposed that the natives of Patagonia were larger than those of any other nation. Yet we have no recent authentic account of any individual of that tribe who measured above six feet six inches and a fraction, or more than forty-eight inches around the thorax, according to Wallace and Cordova. They are even inferior

to the Osages and Blackfeet Indians of North America, who are sometimes above seven feet in height, according to Catlin, whose portraits represent them as smaller round the chest than Europeans.

But the Irish giant, whose skeleton is now in the London College of Surgeons, measured eight feet four inches,—one of the guards belonging to the King of Prussia, eight feet six inches,—a yeoman in the service of Duke Frederic of Hanover, the same. There have also been men in England, Scotland, Sweden, Denmark, and Russia, above eight feet in height, and many who have measured from fifty-two to fifty-six inches around the thorax, without being unusually fat. According to numerous measurements of M. Quetelet and Professor Forbes, the average stature of the Irish, Scotch, and English adult students in the Universities of Cambridge and Edinburgh, is above five feet nine inches; which exceeds that of the French and Belgians, who are taller than the inhabitants of Spain, Portugal, Italy, and Greece. The beautiful Adonis was five feet eight inches, and the Venus di Medici about five feet,—which may be regarded as the mean stature of the men and women of southern Europe.*

* But there is reason to believe that in all parts of Europe, the finest specimens of manly beauty, strength, activity, and intelligence, have been found most frequently among individuals of moderate stature, corresponding with the Grecian model; which

We also learn from Professor Forbes, that the better classes in Ireland are taller, heavier, and stronger, than the same classes in Scotland, who are superior to the same classes in England.* Is this because the temperature of Ireland is more uniform, being less exposed to the cold east winds from the continent, and more open to the prevalent west winds from the Atlantic? or is it because the Irish consume less animal food and more potatoes? In favour of the former hypothesis it may be observed, that in the maritime climate of Japan, the natives are larger and stronger than in the same latitudes of China, where the extremes of winter and summer are great;—that in the tropical islands of the Pacific, where the temperature is mild and uniform, the inhabitants are much larger, stronger, and better formed, than in the same latitudes of Africa, Asia, South

may therefore be regarded as an example of the perfect average man. Alexander the great, Julius Cæsar, Cromwell, and the Duke of Wellington, were of nearly the same stature as that of the Adonis, and Napoleon considerably less. It is evident, however, from all the foregoing facts, that the average stature of man varies in different climates.

* For example, the mean height of the Irish, with shoes, was 70·2 inches, of the Scotch 69·3, of the English 68·9, and of the Belgians 68·3, which is, perhaps, very near the average among the French and Germans. But among eighty students of Cambridge, (belonging chiefly to the aristocracy of England, which are somewhat taller than the lower orders,) M. Quetelet found the average height to be five feet nine inches and three-fifths, which is considerably above the average stature in both the north and south of Europe.

America, and New Holland, where the temperature rises twenty or more degrees higher, and falls as many degrees lower at night. For tropical islands are perpetually fanned by the trade winds, the temperature of which varies only a few degrees.

In regard to the influence of climate on the size and configuration of the brain, we are yet greatly wanting in accurate information. But some valuable facts have been recently collected and published by Dr. Morton, in a work entitled *Crania Americana*,—from which it would appear, that among the least educated classes of the English, Scotch, Irish, Germans, Swiss, Dutch, and Anglo-Americans, the head is larger than among any other race. That this difference depends more on climate, geographical position, and other physical influences, than upon civilization, would appear from the fact, that he found the mean capacity of the skull greater in three Esquimaux, than in seven Chinese, in the ratio of eighty-six to eighty-two cubic inches ;—greater among the barbarous tribes of America, who reside in the temperate and higher latitudes, than among the partially civilized Peruvians, in the ratio of eighty-two to seventy-six cubic inches, and seventy-nine in the Mexicans. The head is also larger among the Tartars than the Chinese, Hindoos, and other inhabitants of southern Asia.

The relative capacity of the skull in what has

been called the five different races of mankind, was ascertained by filling it with white pepper seed, which was afterwards measured, and is represented in the following table of Dr. Morton:

	Number of skulls.	*Average.*	*Capacity in cubic inches.*	
Caucasian	52	87	from 109	to 75
Mongolian	10	83	93	69
Malay	18	81	89	64
American	147	80	100	60
Ethiopian	29	78	94	65

Thus we perceive, that the brain is nearly as large among the savage tribes of northern America and Asia, as among the civilized inhabitants of Europe, and smaller among the tribes of central Africa, than among any other people, excepting the natives of tropical America. It is not, however, so much in the aggregate volume or weight of the brain, that the superiority of man consists, as in the development of its anterior and superior portions. Moreover, if the brain of the negro were of the same size and form as that of the European, it would still be inferior in firmness of structure, and therefore in power, because not supported by so large a thorax, nor supplied with such an abundance of good arterial blood, the vital properties of which depend on the amount of respiration, (*ceteris paribus*,) which is diminished by an elevated temperature of the atmosphere, as will be further proved when I come to treat of temperaments.

Should it be urged that the magnitude and form of the head, on which the intellectual and moral character of nations so much depends, are determined chiefly by regimen, modes of living, political, religious, and social institutions—I reply, that all of these are no less modified by climate than the geographical distribution of plants and animals:—that if the natives of the polar regions live chiefly on flesh, and clothe themselves with skins, it is because the climate does not afford grain, grass, fruits, cotton, flax, wool, and silks; all of which abound in warmer latitudes: — that if the Budhists, Brahmins, and Essenes, of southern Asia, abstained from animal food and spirituous liquors, it was because they are injurious to health in hot climates:—that if, like the priests of Egypt, they enjoined the frequent use of the cold bath as a religious duty, it was because they found it salutary in a burning climate:—that if they had resided in Russia, they would have substituted in its place warm bathing, which the Russians regard as a panacea:—that if the laws of Moses against the use of pork, hares, rabbits, all carnivorous animals, shell fish, and fat of every description, were adapted to the climate of Palestine, they are constantly violated by even the Jews, in the higher latitudes of Europe, Asia, and America; for no laws will ever be long and widely obeyed, unless founded on, and in harmony with, those of nature.

Thus it is manifest, that the diet, clothing, habitations, manners, customs, and religious ceremonies of mankind, are greatly modified by geographical position,—that "creeds and morals vary in every clime, growing like herbs upon the soil,"—that the physical character of nations, and even their political institutions, depend greatly on the region in which they are created. For in countries where the climate is unfit for agriculture, the population must necessarily be poor, thinly scattered, and separated into numerous tribes of wandering shepherds, robbers, and hunters, who cannot unite under regular forms of government, nor make any considerable progress in civilization, arts, science, and general improvement. As the higher intellectual and moral faculties are but little exercised, they are imperfectly developed, and the animal feelings greatly predominate.

But in countries where the population is dense, all the higher faculties are stimulated to exertion, by the prospect of obtaining wealth, pleasure, distinction, or power,—which are both the cause and effect of improvement of the nobler faculties. Even the organs of voice are modified by climate. And as among barbarous tribes, the objects are few about which the mind is employed, language is poor, or deficient in copiousness and variety. On the other hand, I fully agree with Mr. Lawrence, that "bad government, oppressive laws, neglected education, bigotry, fanaticism, and reli-

gious intolerance, will counteract the noblest gifts of nature, and plunge into ignorance, degradation, and weakness, nations capable of the highest culture, the most splendid moral and intellectual achievements." If the climates of India and China are less favourable to a high developement of physical, intellectual, and moral endowments, than those of Europe, the inhabitants have also been kept stationary for the last 2000 years by the institution of casts, and the misfortune of a hieroglyphic language; so that the finest portions of Asia are buried in profound darkness, and prevented from improving their condition; while in Russia, the mass of the people have been hitherto degraded to the condition of serfs, and sold with the estates on which they labour, like beasts of burden.

CHAPTER II.

"If the human mind can ever flatter itself with having been successful in discovering the truth, it is when many facts, and these facts of different kinds, unite in producing the same result."

BAILLIE.

It is still an unresolved problem among Philosophers, whether all the varieties of mankind have resulted from the influence of climate, geographical position, and different modes of living, as supposed by Herodotus, Diodorus, Hippocrates, Buffon, Zimmerman, Forster, Herder, Smith, and some others,—or from an original difference of race, as maintained by Voltaire, Humboldt, Adelung, Caldwell, Lawrence, and others. The most prevalent hypothesis of the present day is, that all the nations of the earth may be traced to different races, which have been mingled by conquests, colonizations, marriages, &c. Without denying that all of them may have descended from the same original stock, Blumenbach has reduced the whole to five distinct classes, which he terms the *Caucasian*, the *Mongolian*, the *Malay*, the *American*, and the *Ethiopian races.*

To the first of these classes belong the Hindoos, Arabians, Persians, Egyptians, Lybians, Phœnicians, Greeks, Romans, Saxons, Celts, with their descendants, now spread over Europe and many

other parts of the world. To the second, or Mongolian family, belong the ancient Scythians, and their descendants, the modern Tartars of central Asia, the Chinese, Japanese, the Indo-Chinese, and the various tribes of northern Asia. To the Malay race belong the natives of Malacca, Borneo, Sumatra, Java, New Zealand, the Philippine, and other islands of the South Sea. The fourth class embraces the numerous tribes of America, from the arctic ocean to Cape Horn; while the black natives of central Africa, New Holland, and New Guinea, belong to the fifth, or Ethiopian race.

It is maintained by Mr. Lawrence, in his very able and learned work on the Natural History of Man, that "external agencies, whether physical or moral, will not account for the bodily and mental differences which characterize the several tribes of mankind,—and that they are the offspring of natural differences in the breed or race." (pp. 300, 387, 442, 486.) M. Quetelet also observes, in his late Treatise on Man, that "different races must be admitted, although the characters on which these distinctions are established have not been sufficiently defined." And he adds, "how can we study the modifications which the elements relative to man, as well as their laws of developement, undergo in the different races, *when we have not settled the point of commencement?*"

In regard to the first abode of mankind, termed he Garden of Eden, or the terrestrial Paradise

various opinions have been advanced by different nations and individuals. By some of the Hindoos, it is supposed to have been situated in the beautiful vale of Cashmere; and by others in the tropical island of Ceylon. Sanson, Roland, and Calmet, have placed it in Armenia, between the sources of the Tigris and Euphrates,—Abram, Le Clerc, and Heidegger, in Assyria near Babylon, —others in the neighbourhood of Damascus,—others in Arabia Felix—and some in Palestine. But the most improbable of all the hypotheses I have met with is that of Buffon, Adelung, and Herder, who supposed that mankind began their existence on the elevated table lands of central Asia, or about Mount Caucasus, where the climate is extremely rigorous during the greater part of the year. For if the human race began in a rude state of nature, ignorant of agriculture and the arts, it must have been in a tropical or warm climate, in which the earth would spontaneously supply an abundance of nutritious fruits. Nor is it possible, that men could have existed in the climate of central Asia without clothing, unless covered with hair.

If we are to take the description of Eden contained in the second chapter of Genesis, it would seem to have embraced a large portion of southern Asia, extending from the Ganges on the east, to the Euphrates on the west. For it is said to have been watered by the *Pison*, the *Gihon*, the *Hiddekel*, and the *Euphrates*. It is true, that

none of these have been clearly identified with known rivers, except the Euphrates. But that Pison was the Ganges, might be inferred from its being said to " encompass the whole land of Havilah, where there is gold, bdellium, and the onyx stone,"—which have been found in the alluvial deposits of the Ganges. And that the Gihon was another name of the Indus, might also be inferred from the passage in which it is said to " encompass the whole land of Ethiopia," which was the ancient name of a province of western India, as shown by Godfrey Higgins. Finally, that the Hiddekel was identical with the Tigris, is indicated in the 14th verse, in which we read, that it " goeth to the east of Assyria," which really was bounded eastward by the Tigris, and that the " fourth river is Euphrates."

That all the different nations, tribes, and families of mankind belong to the same genus and species, is now universally admitted by physiologists. And that they have all descended from the same primitive stock, which began its existence in some part of southern Asia, would also appear from the united testimony of profane history. It is maintained by the learned Dr. Prichard, in his work on the Physical History of Man, that all the different races of the earth, orginated from one family. But he thinks that cultivation, or civilization, has had more influence in producing varieties, than climate, geographical position, or any other known cause. (pp. 155, 194—222. 1st. Ed.)

The late Godfrey Higgins has also shown, in his very elaborate work on the origin of nations, languages, and religions, that southern Asia was the ancient mother of nations,—that men gradually spread themselves from India and Arabia, across the Red Sea to Ethiopia, whence they descended the Nile to Lower Egypt, and from north Africa to other portions of the continent:—that from the Peninsula of Malacca, they passed over to Sumatra, Borneo, New Guinea, New Holland, New Zealand, and other islands of the southern Pacific:—that from the north of India and Persia they extended over ancient Scythia, Siberia, and the north of Europe,—while to the westward, they spread over Asia Minor, Greece, Italy, Spain, Gaul, Britain, Germany, and every part of Europe:—that the ancient *Sascæ* or Saxons, who occupied the greater part of Europe before the arrival of the Celts, were in fact Scythians, that came originally from the north of India and Persia:—finally, that the Saxons, Celts, and Scandinavians, were successive swarms of the same hive, sent out from middle Asia, and arrived in the west at different periods, like the colonies sent from Great Britain to America, Africa, and Australia; the difference in their dialects being such as would naturally arise in a few hundred years in unwritten, or even in written languages. (Anacalypsis.)

Dr. Prichard also states on the authority of Herodotus and Diodorus, that the Saxons were

Scythians, who were originally a colony of Medes, —and that the Tartars of middle Asia, like the Getæ, Thracians, Goths, and Sarmatians of northern Europe, were descended from the same stock. He further observes, that between all the native dialects of north Africa there is a close affinity :—that accurate observations on the language and customs of the various tribes scattered over the South Sea Islands, put it beyond a doubt, that they are all descended from one stock, and came originally from southern Asia :—but that owing to their having migrated at very early periods, before the language and institutions of the mother country were fully formed, few remains of its ancient mythology, manners, and customs, have been found among them ;—and that notwithstanding the difference between the languages of China, India, and Egypt, Sir William Jones has traced many striking affinities in their ancient civil and religious observances. (Op. Cit. pp. 147, 478, 484, 500, 544.)

Dr. Prichard further states, that the primitive language of Persia, called the Zend, was only a dialect of the ancient Sanscrit, from which all the modern languages of India are derived ; and differed but slightly from that of Egypt, Phœnicia, and Judea,—that the present Brahmins of Benares still perform the same religious ceremonies which were practised in ancient Persia, whose dominion was established over a large portion of Asia, as early as the time of Abraham, and

before the extension of the Syrian power,—that the modern Parsees, who are descendants of the ancient Persians, still retain the Zend and Pahlavi dialects:—that according to an old poet of Sidon, the founder of Babylon was a Phœnician—and that the same astronomical formulæ were employed in Chaldea as in Egypt. (Id. pp. 450, 469.)

Sir Edward Bulwer justly observes, that "when history fails in accounting for the foreign extraction of any people, or when it is manifestly mistaken, the question must be determined by the analogy of languages, which is at once conclusive, if nothing else were left." And it has been shown by Godfrey Higgins, that *there is not one written language, in which several words of every other written language may not be found:*—that according to Van Kenedy, 900 Sanscrit words have been discovered in the Persian, Greek, Latin, German, and English languages—339 in the Greek; 319 in the Latin; 263 in the Persian; 163 in the German; and 31 common to them all:—that according to Cluverius, nearly 1000 Hebrew words have been found in other languages:—that Dr. Geddes has shown nearly all the genuine Saxon words to be either Hebrew, Chaldee, Arabic, or Persian:—that Sir William Drummond has traced a radical affinity between the Coptic or Egyptian, the Ethiopic, the Chaldee, Arabic, and Hebrew:—that General Vallancy has shown the ancient Celtic to be a dialect of the Phœnician, which

Le Clerc and others have proved to be nearly identical with Hebrew, and closely allied to the Sanscrit and Zend, from which the ancient Scythian, Manchoo Tartar, German, and Celtic are derived, as the Italian, French, and Spanish, from Latin :—that Vallancy further asserts, that almost every word in the first twelve verses of the Iliad may be traced back to Phœnician, Egyptian, Chaldee, and Hebrew origin,—and that in the native Irish language, which is Celtic, he found fifty words relating to augury and divination, every one of which was oriental. (Anacalypsis, vol. i. pp. 449, 454, and 461.)

Corresponding with the foregoing facts, we are informed by Jacob Bryant, in his very learned work on Heathen Mythology, that the Greek words ξωη life, ξωον an animal, and ξωειν to live, were derived from *zoon* or *zoan*, a Phœnician and Egyptian name of the sun,—showing that in the earliest times, the Greeks regarded life as an emanation from that luminary, as maintained by Macrobius in the third book of his Saturnalia, (p. 282). And Wilkinson states in his late work on Egypt, that *onh* is still the Coptic word for life, the male principle of which was termed *linga,* and the female *yoni*, as in ancient India, where the genetic power of solar heat was represented by the male and female organs of generation. (p. 523 edition 1.) Bryant has further shown, that the Greek word Αιθερ, *Aither*, was derived from the word *Aith*, *Ath*, *Eth*, or *Oth*,

(all of which are modifications of the same word, signifying the sun, among the Egyptians, Phœnicians, and several other oriental nations,) and from *Aur*, *Our*, or *Ur*, meaning light or fire; and when joined together, signifying solar light or fire. But both of these words are also Hebrew; and Dr. Adam Clarke says, in his Commentaries on the first chapter of Genesis, that אות, *Ath*, *Eth*, or *Oth*,* signifies the sun, the lights of heaven, and the substance of all things; while the word אור, *Aur*, *Our*, or *Ur*, designates light, fire, lightning, and sometimes the rainbow. Parkhurst also observes, that *Aur* denotes the extreme fluidity of light, or the continual flowing of its particles from the sun, which in the 24th Psalm is termed the king of glory,—a word that plainly implies the action of light:—that in the 31st chapter of Job, *Aur*,† is employed to signify the

* Bryant maintains that the Greek word Θεος, was derived from the Egyptian *Thoth*, which is doubtless a modification of the Hebrew and Phœnician *Oth*, the sun,—"on which the young nations of the world gazed with the freshness of childhood, until their admiration became a worship,—wondrous and divine still, after all our Astronomies and Almanacks." (Carlyle's Hero Worship.) Bryant further states, that *Bel*, *Bal*, or *Baal*, was a Babylonian title of the sun, and when compounded with *Orus*, as in *Bel-Orus*, signified the Lord of Light. Dr. Prichard also observes, that *Sunuh* was one of the Sanscrit names of the sun, which in the Manchoo Tartar language is *Shun*, and *Sonne* in German. The Latin verb *uro*, I burn, is also derived from *ur*, fire.

† He further states on the authority of Varro, that the Latin word *aurum*, was derived from *Aur*, meaning the golden sun, with his heavenly light. Nor is it less certain, that the Greek

sun; and fire in the book of Ezekiel, as in many other parts of the Old Testament.

Bryant has also shewn that the Greek word Ἑλιος, or *Helios*, is radically identical with the Phœnican word *Elion*, a compound of *El* or *Eli*, and *On;* both of which were primitive titles of the sun, and signified *Deus Sol.* With Macrobius, he maintains that all the Grecian names of Deities were originally titles of one God, and related to the sun or solar fire:—that from the names of places, mountains, groves, fountains, *mounds*, *towers*, *temples*, and *obelisks*, consecrated to the sun, and called after him, the Greeks invented ideal gods, heroes, and the histories of what they had done,—that the name of Persia was taken from *Parez* or *Perez*, an eastern name of the sun,—that Syria was derived from *Sur* or

word Αηρ, and the Latin *aura*, signifying air, were derived from the same Hebrew and Phœnician root;—that the spirit termed רוח, described as moving *on the face of the waters*, and as *breathed into the nostrils of man*, like the Πνευμα, the ψυχη, and Ανιμος of the Greeks, literally means breath, the *air in motion*, and *animal life;*—that there is not a single word in the Old or New Testament, nor in any written language, to designate the human soul, or any spiritual essence, which does not also signify air, light, or fire. But from the time of Orpheus to that of Hippocrates, and even down to the period of Cicero, the Greeks and Romans confounded air, (because ignorant of its compound nature, and of the limited extent of the atmosphere,) with the more subtil and all-pervading æther, which they were fully aware extended throughout universal space. Hence the assertion of Aristotle, that nature abhors a vacuum, which, he very truly observes, would destroy all motion.

Suria, a Chaldean title of the sun,—which is also termed *Surya* in Sanscrit,—that Ethiopia was formerly called Atheria, from *Ath* and *Ur*, or from *Aythur*, meaning land of the solar fire:—that the Greeks took their appellation of Ἑλληνες, *Hellenes*, or *Heliadæ*, from *Helios*, implying their descent from the solar race. (Heathen Mythology, vol. i. pp. 56, 96; vol. ii. p. 405.)

Dr. Prichard also informs us, that one of the Sanscrit names of the sun is *Hailigh* or *Hailis*, and is doubtless the same word as *Helios* or *Helion*,—which is one of the titles employed in the Hebrew Bible to designate the supreme Deity, according to the very learned Jerome, who is represented by Parkhurst as the most skilful Hebracian among the Fathers. Another title of the supreme Creator in Hebrew is *Adonai*, which, according to Bryant, is compounded of three Phœnician words, *Ad*, *On*, and *Ai*,—all of which designated the sun, who was worshipped as the creative and formative God in ancient Tyre, Sidon, Canaan, and Carthage. Another and still more common title of the supreme Deity in Hebrew, is the word אל, *Al*, *El*, *Eli*, or *Elion*,—all of which are modifications of the same word, which we have already seen was a Phœnician, Sanscrit, and Greek name of the sun. We also read in the first chapter of Genesis, that in the beginning, אלים, *Elohim*, created the heavens and the earth.

The ablest Hebrew scholars differ in opinion as to whether the word *Elohim* is singular or

plural, as it sometimes agrees with singular, and at other times with plural verbs. But Parkhurst maintains, that it generally answers to the Greek word Θεος, and expresses the universal extension or omnipresence of the Divine spiritual essence,—moreover, that the idea of this attribute was taken from celestial fluid in its three-fold condition of *light*, *fire*, and *spirit*, operating jointly in every effect. He also quotes the declaration of Diodorus and Varro, that the Egyptian *Jove* was identical with the *Jehovah* of the Jews,—that with some dialectical variations, the Phœnicians, Etruscans, Romans, and other ancient nations, gave the same title to the all-pervading fiery *Æther* that was supposed to actuate the universe, and to endow all beings with life. He further states on the authority of Servius, that the Deity was termed *Al* or *El* in the Phœnician language, —and that the Canaanites had a tower or temple dedicated to the sun, אל, *Al*, according to Josephus. (Hebrew Lexicon.)

In accordance with these remarkable analogies, it is stated by Godfrey Higgins, that the root יהוה *Yeye* or *Yehovah*, signifies in both Hebrew and Sanscrit, *to be*, *to live*, and the *self-existent fire*, which under that sacred title, the Brahmins chaunted in their service. (Anacalypsis, vol. i. pp. 430, 468; and vol. ii. p. 249.)

Nor is it surprising that the language, and many of the Jewish customs, so nearly resembled those of several oriental nations, when we reflect, that

Abraham was a Chaldean,—that his descendants resided long in Egypt, during which time they must have adopted the language, manners, and opinions of that country,—that from Egypt they removed to the Phœnician land of Canaan, where they very soon adopted the worship of *Baal* and *Molech*,—which was practised to a greater or less extent, from the time of Joshua until they were carried away captive into Babylon, (from which the ten tribes never returned;) and where they learned the Chaldee letters, in which the Hebrew Bible is written.

Like the ancient Hindoo word *Alkache*, the Arabic name of God, *Allah*, is doubtless a modification of the Hebrew אל *Al.* We are also informed by Diodorus, that among the Egyptians, *Jove* was a personification of the *celestial Æther*, which they called *Youpiter*, because the spirit of life, and the generator of all things, according to a priest of Memphis,—and that the Greeks derived their word ζεω, to burn, from his name Zeus. (Lib. i.) And Servius states, that Natural Philosophers will have *Jupiter* mean the *Æther*, whence he is called Ζευς, from ζειν to be hot or warm. (Æn. i.) Similar expressions are found in Euripides, who represents the unbounded *Æther* which encircles all things as *Jove.* The Roman poet Ennius also says, that all invoke the shining Æther as *Jove.* And Virgil calls him *Pater Omnipotens ÆTHER.* (Georg. ii. line 325.)

Plutarch further states, that *Osiris*, an Egyptian name of the sun, signified likewise the *Æther* or active principle in Nature, and *Isis* the passive elements from which everything is formed. Macrobius also maintained, that there exists a luminous, igneous, and subtil fluid, which, under the name of *Æther* or *spirit*, fills the universe,—that it is the essential principle of motion and life; and is in fact the Deity. (Somn. Scip.)

The truth is, that the worship of the sun, or of that ætherial fire which animates the *infinitude* of suns which glitter in the boundless firmament, was practised in Memphis and Thebes, Nineveh, and Babylon, Tyre and Sidon, Balbec and Jerusalem, long before the time of Abraham,—that it prevailed from Ethiopia to Siberia, and from eastern Asia to the remotest borders of western Europe, if not in every part of the inhabited world,—for it may be traced in the language, mythology, and monuments of north and south America. Temples dedicated to the sun have been discovered in the ruins of Palenque and other ancient cities of central America. We also learn from Robertson's History of America, that the Iroquois, Hurons, Algonquins, Natchez, and many other Indian tribes, performed the religious ceremony of dancing around what they called the *holy fire*, into which they cast a portion of everything they used, as a sacrifice in honour of the sun. (Vol. ii. B. iv. p. 23.)

The same fact is attested by Adair and many

other travellers. Mr. George Catlin also states, that the Mandans of the Upper Missouri, "offered sacrifices, prayers, and thanksgivings, to the *Great Spirit who lives in the sun*,"*—that they had a tradition concerning the transgression of the first woman, the general deluge, the miraculous conception, birth, subsequent miracles, and death of a Saviour. (Manners, Customs, &c. of the N. Amer. Indians, vol. i. p. 180; vol. ii. p. 135.)

We are further informed by Lord Kingsborough, that the native language of Mexico, (like the Saxon and Celtic of Europe,) is full of Hebrew words,—that the people had a tradition of the flood, performed the rites of circumcision, baptism, and auricular confession, sacrificed their first born, like the ancient Phœnicians, Syrians, and other oriental nations, including the early Jews; and that they expected a Messiah. (Antiquities of Mexico, vol. vi.)

It is also stated by Higgins, on the authority

* There is reason to believe, that the pyramids of Egypt, the turrets of China, the cromlechs of the Druids, the round towers of Ireland, and the mounds of America, were originally intended as monuments of the same primitive worship practised in groves and high places by the Canaanites, and all the ancient nations of the earth. For it is stated by Parkhurst, on the authority of several distinguished authors, that obelisks were originally dedicated to the sun. And Volney says, that the Egyptians represented the sun by a cone, fire by pyramids, and the earth by a revolving cylinder. Nor is the opinion that the pyramids were consecrated to the worship of fire inconsistent with the general belief, that the kings of Egypt were buried in their vaults.

of De Guignés, Bergeron, and Paravey, that an ancient Chinese History, called the Chan King, treats of the terrestrial Paradise, the fall of angels and of man, the sabbath, confusion of tongues, manna in the wilderness, the Trinity, and of the Holy One in the west, who was incomprehensible, and one with *Tien*, for whom the nations of the earth are waiting like plants for a refreshing shower, as taught by Confucius nearly 2400 years ago. (Op. Cit. vol. ii. pp. 28, 33.)

Thus it would appear from the language, traditions, and monuments of America, that it was originally peopled from the Asiatic continent. In opposition to this view, we are told by Voltaire, that the same creative Power which caused grass and trees to grow on the American soil, could place man there. Dr. Prichard and Mr. Lawrence also admit with Buffon, that, excepting the regions north of the Baltic in the old world, and those north of Canada in the new, no quadrupeds were originally common to both. But the absence of the horse, ox, sheep, dog, and other domestic animals of the old world, in the greater part of the American continent when first discovered by Columbus, tends rather to prove that the new world was elevated from beneath the ocean at a more recent geological epoch, than Asia, Africa, or Europe,—an hypothesis which is corroborated by the great number of volcanos and earthquakes now in operation in various parts

of South America, Mexico, and the West Indies, —while it is well known that large districts in Chili, Mexico, and other parts of the country, have been raised several feet within the last few years. But as if the recent origin of a Continent were a proof of inferiority, Dr. Caldwell rejects the hypothesis as " a calumnious fabrication, invented for the purpose of depreciating the new world."

Others have maintained, that if America had been peopled from Asia, the natives would not have been ignorant of letters and the use of iron. But as Higgins observes, this may have been owing to their separation from the primitive tribes of the old world, before they had advanced beyond the savage or pastoral state. And he thinks that, as the horse was unknown in America previous to the time of its discovery by Columbus, the pictorial representations of that animal by the Mexicans, prove that their progenitors came originally from the old world.

If then it be true, that Africa, New Holland, and the various islands of the Pacific, were peopled from Southern Asia, which, as we have seen, was the seat of the Garden of Eden,—that ancient Scythia, Northern Asia, the whole of Europe, and the new world, were peopled from the same prolific region,—there is no foundation in nature for the division of mankind into three, five, or more primitive races. We are therefore authorized to

conclude, that all the nations, tribes, and families of the earth are descended from one and the same original stock,—in other words, that " God hath made of one blood all the nations that dwell on the earth." Nor will the admission of five or more primitive races explain the endless varieties of colour, form, &c. of the human species—why, for example, the Patagonians are so different from the natives of Terra del Fuego on the one hand, and those of Peru, Brazil, Guiana, and Mexico on the other,—why the osage and black feet Indians are larger than any other tribes of North America, and the Esquimaux little above the stature of dwarfs; while they are all supposed to belong to one and the same distinct race. Again, there is a far greater difference between the tribes of Northern Asia, Europe, or even of Tartary, and the natives of China, (all of whom are regarded as belonging to the Mongolian race,) than between the latter and the Hindoos, Arabs, Egyptians, Persians, Georgians, and Circassians, who are equally different from the Greeks, Romans, Germans, Dutch, British, and other nations of Europe,—all of whom are supposed to have descended from the Caucasian stock. There is also an endless diversity among the tribes which constitute the Negro and Malay races, as they are called.

Having in the preceding chapter examined the influence of climate on the stature, magnitude of

the chest, size and form of the head, intellectual and moral character of the human race, I proceed to inquire how far it modifies the complexions of mankind. Dr. Prichard maintains on the authority of Herodotus, Diodorus, the travels of Norden, Volney, Sonnini, and Denon, that the original colour and general configuration of the ancient Egyptians were those of the negro race, with dark skin, woolly hair, prominent cheek bones, low and narrow forehead, thick lips, flat nose, protruding eye-balls, and short stature. In support of this opinion, Godfrey Higgins states, that the most ancient statues of India and Egypt are black, with curly hair, thick lips, and flat nose, —that in Greece, which was originally peopled from Southern Asia and Northern Africa, the statues of Jupiter, Hercules, Bacchus, and other gods, were of the same colour,—from which he inferred, that all the first inhabitants of the earth were black, and gradually changed through every gradation of colour, on spreading over the higher latitudes.

Yet Dr. Prichard thinks, that "climates have very inconsiderable and doubtful effect in exciting varieties of complexion,"—which are owing more to civilization or "cultivation, than to any other known cause." (Physical History of Man, pp. 155, 194, 222.) But it is only in the hottest portions of the earth that man is perfectly black, as among the negroes of Soudan, Bennin, Da-

homy, Ashantee, Loango, Angola, Benguela, and other parts of central Africa, where the temperature rises higher than in any other quarter of the globe, and from 105° to 113° in the shade, during the heat of the day, in places where there is no sea breeze; as we learn from Denham, Clapperton, and other travellers. If we pass to the more temperate regions of North and South Africa, we shall find that the natives are neither black nor white, but exhibit various shades of colour, from dark brown, olive, and dusky red, to a tawny yellow, with black and slightly curled hair, as among the Berbers, Caffres, Boshuanas, Hottentots, and several other tribes.

We have also seen, that in the tropical portions of New Holland, the temperature approximates that of central Africa, owing to the absence of mountains, the prevalence of large sandy deserts, and the scarcity of rain,—that in this dreary region, the mercury sometimes rises to 112° in the shade, during the hot winds from the interior, according to Mr. Lang,—and it is known that the natives are almost as black as in central Africa. The climate is also excessively hot in the large tropical islands of New Guinea, Borneo, Java, and Sumatra, in consequence of their vicinity to Southern Asia and New Holland. As might be supposed, the natives exhibit various shades of black, dark brown, and dusky olive. But in the smaller tropical islands scattered over the Pacific, the temperature scarcely every rises above 85° or

90° in the shade, and the complexion of the natives is proportionally lighter, with long straight hair, regular features, and fine symmetrical forms, compared with those of central Africa, southern Asia, tropical America, and New Holland.

Moreover, it is well established, that the inhabitants of southern India, China, and Arabia, are several shades darker than in the northern portions of those countries; and more dark than the Japanese, who live in a more temperate climate. We also learn from Niebuhr, De Pages, and Frazer, that in the burning province of Yemen, or desert of Akhaf, the Arabs are of a colour approaching that of the negro, and have curly hair. But Bruce states, that among the mountains of Ruddua in the north of Arabia, where water freezes, the natives have red hair, blue eyes, and fair skin. Nor is it less certain, that the Persians and Turks are darker than the Georgians and Circassians,—that in the north of Spain, Italy, and even France, the inhabitants are much fairer than in the southern provinces,—finally, that in England, Scotland, Ireland, Belgium, Holland, Germany, Sweden, Denmark, and Russia, where the mean temperature of summer is lower than in any other part of the world in corresponding latitudes, and varies from 60° to 66°, they are of a ruddy white complexion, with fair hair, and blue eyes, modified, however, by mixture with the natives of other climates, which produces an endless variety of shades.

But why should I multiply words to prove that the sun with his different coloured rays, is the great Painter of Nature? For *no indigenous white race has ever been found within the tropics, and no black nations in the middle or higher latitudes*, if we except the dark brown inhabitants of Van Dieman's land, who, as Dr. Prichard observes, may have come from New Guinea, the tropical portion of New Holland, or some other hot climate. Is it not also an incontrovertible fact, that Europeans become several shades darker, and often quite brown, after residing fifteen or twenty years in tropical India or south America? Nor is this any more remarkable than that the blush of the apple, peach, and other fruits, should be always deepest on the side exposed to the sun,—that the sky, the ocean, the evening clouds, the plumage of birds and insects, with all the adornments of the external world, should be always most richly and variously coloured where the power of the sun is greatest; and diminish on to the polar regions, where they are reduced to a dull monotonous mixture of brown and leaden grey in summer, and to whiteness during winter, —that those parts of animals from which the solar rays have been excluded, are pale or white, like celery and other plants when kept in the dark,—or that the offspring of brown mice when constantly kept in dark cellars, is often white, with reddish eyes.

Should it be asked why the natives of tropical America are less dark than those of central Africa, southern India, New Holland, New Guinea, Borneo, and Sumatra, I answer, that the mean temperature of South America is greatly mitigated by the continual exposure of its eastern coast to the trade winds,—by the elevation of Chili, Peru, and Mexico, from eight or ten to fifteen thousand feet above the ocean,—and by the small amount of dry land between lat. 10° and 30° N. giving to Guatemala and Mexico the character of a maritime climate. Accordingly, we are informed by Ulloa, Bougouer, and other travellers, that on the table lands of Peru and Mexico, the natives are much fairer than on the low and level plains of Brazil, where Dr. Prichard says they are nearly as black as Africans. We also learn from the surgeon who accompanied Captain Beechy in his voyage of discovery in the Pacific, that among the Araucoans who inhabit the temperate climate of Chili, he found several individuals who had grey eyes, which is never the case with persons of dark bronze or copper complexion.

But it has been stated on the authority of Humboldt, that the colour of the native Americans is nearly the same in all latitudes; consequently that difference of climate will not explain all the varieties of complexion in the human species. To which I answer, that the opinion of Humboldt is refuted by the testimony of nume-

rous accurate observers,—and that it is stated by Humboldt himself, that on the north western coast of America, around Cloak Bay, in lat. 54°, the natives have large eyes, European features, and are not darker than the peasantry of Germany. It is also stated by Say, Major Long, and other travellers, that near the sources of the Mississippi, the natives are much fairer than the more southern tribes of North America; and that many individuals have light flaxen or yellow hair. Mr. Catlin further states, that among the Mandans who resided in lat. 46° N. and had become so far civilized as to have comfortable dwellings, with the art of manufacturing vessels of pottery, there were females almost white, with hazel, blue, and grey eyes, regular features, and hair of every colour, except red and auburn. (Manners, Customs, and Condition of the North American Indians, vol. i. p. 94.)

Should it still be urged, that the general complexion of the native Americans is that of iron rust, while that of the various tribes in northern Asia and Europe is yellow or tawny, it may be answered, that all barbarous nations are continually exposed to the sun and air during summer, and mostly confined in smoky dwellings amidst filth during winter, while many of them employ red paints. But it is obvious, that if the whitest nations of Europe had been exposed in the same manner for a sufficient length of time, their skin

would be thick, coarse, and yellow, the hair and eyes black. For the peasantry of Switzerland, Germany, France, Poland, Sweden, and Russia, are of a brownish yellow colour, and several degrees darker than the inhabitants who remain chiefly within doors during the heat of the day.

In support of his theory, that civilization or what he calls "cultivation, produces greater varieties of complexion than any other known cause," Dr. Prichard says, that the Moorish ladies of north Africa, who remain in the shade, are often beautifully fair; while their brothers, who are much exposed to the sun, are brown or olive:—that the Brahmins of India, (which is equally true of the wealthier classes in general, including the Parsees,) are several shades lighter than the field labourers, boatmen, and sailors:—that the Tartars who conquered China about two centuries ago, and adopted the habits of civilization, have become much fairer, and now often have blue eyes. But Dr. Prichard seems to have overlooked the fact, that in warm climates, the temperature, is 20° or 30° higher in the sun than in the shade,—a difference almost equal to that between the tropical and middle latitudes,—*so that what he calls cultivation means protection from the influence of external temperature, which is the principal element of climate.* He admits, that the Kabyles of Tunis and some of the high mountains in North Africa, (where the climate re-

sembles that of Greece and Italy,) are of a fair and ruddy complexion, with hair of a yellow or reddish colour, as stated by Shaw, Hornemann, and Marsden,—while the Tuarics of the Great Desert, who speak a dialect of the same language, are of a dark brown complexion, as among the natives of Ceylon, Bengal, Malacca, Penang, Madagascar, and other tropical climates. Should it still be objected that the inhabitants of northern China are darker than those of western Europe, where the mean annual temperature is nearly the same, I reply, that the average of summer is from 15° to 20° higher at Pekin than in Great Britain, France, Germany, and Holland, the natives of which are much fairer than in Italy, Greece, Spain, and Portugal, where the climate is proportionally warmer.

Dr. Prichard maintains, that " the complexion acquired by exposure to the sun is not imparted by parents to their offspring,—and that no change of climate, however great, or for whatever time its influence may have been exerted, could transform white Europeans into negroes, or even make them approximate in any considerable degree." (Op. Cit. pp. 194, 222.) The same opinion has been embraced by Mr. Lawrence. And Dr. Caldwell maintains, that although the whites in Africa have been somewhat darkened, their constitutions deteriorated, and their numbers reduced, no perceptible progress, or even tendency, has been

made towards their conversion into another race. Nor does he believe that the negro owes his colour to a tropical sun, because those parts of the body which are covered with us, are of the deepest black. But he forgets that in Africa, the natives generally go naked, or nearly so, as among all barbarous tribes in warm climates.

In opposition to the foregoing views, we are informed by Herder, on the authority of several highly respectable travellers in Africa, that the descendants of the Portuguese who settled on the coast of Guinea about three hundred and fifty years ago, are nearly as black as the natives; while in symmetry of form, regularity of features, and general intelligence, they have degenerated in the same proportion. (Philosophy of Hist. vol. i. p. 267).

If, then, there has been so great an approximation of Europeans to the colour and other peculiarities of the negro race in three hundred and fifty years, what changes might naturally be expected to arise in the course of two or three thousand years? Does this not look as if the white might be transformed gradually into the black race? In support of this opinion, Bruce states, that the Jews are black in Abyssinia, brown in Arabia, Syria, and Egypt,—while it is certain that they are much darker in Italy, Spain, Portugal, Greece, and Turkey, than in Britain, France, Holland, Germany, Sweden, and Russia,

where many of them are exceedingly fair and ruddy, with sandy beards.

We also learn from "The Researches" of Claudius Buchanan in India, that in the southern province of Malabar, there is an ancient colony of Jews who are black, and scarcely distinguishable from the Hindoos; whereas the modern Jews who came from Palestine at a much later period are nearly white. (pp. 226—230). It is therefore undeniable, that notwithstanding the rigid adherence of this remarkable nation to their original manners, customs, and modes of living, their complexion is as various as the climates in which they have long resided. Nor is it less certain, that the Arabs who passed over to Africa about a thousand years ago, are much darker than those of Asia; and in the Great Desert of Sahara, they have become nearly as black as the Tibboos and natives of Fezzan.

There is also reason to believe, that in the course of two thousand years, and perhaps a much shorter time, the blackest negroes of central Africa would become perfectly white in such a climate as that of Great Britain, and undergo a corresponding change in their whole organization. For it is stated by Dr. Samuel Smith, in his work on the Varieties of Colour, Form, &c. of the Human Race, that, after the third generation, the descendants of negroes brought from Africa to the United States, are several shades lighter than

their ancestors,—the hair longer, softer, and less curly; the eyes more animated, the mouth smaller, the nose more elevated, and all the features more agreeable, with a corresponding improvement of the intellectual faculties,—and that the change is much greater among domestic servants than field labourers, who are more exposed to the sun. I have also been informed by a highly intelligent gentlemen of colour from St. Domingo, that he has observed a considerable change of his own complexion, and that of his countrymen in general, after a few years residence in Paris or London.

From all the foregoing facts, we are authorized to conclude,

1. That if the climate of the whole earth had been the same as that of central Africa near the level of the sea, ever since the origin of mankind, they would have been everywhere black, with curly hair and dark eyes :—

2. That as the Greeks and Romans, Saxons and Celts, came from southern Asia and northern Africa, they must have originally been of the same complexion and configuration as the present Hindoos, Egyptians, and Moors, who are of a dark brown colour :—

3. That if in all latitudes, the temperature of the earth had always corresponded with that of Britain, France, Germany, and Holland, there would have been no black nor brown nations and tribes :—

4. But that as the temperature of the globe is diversified by the inclination of its axis, the unequal distribution of land and sea, mountains and valleys, dense forests and sandy plains, there is a corresponding variety of colour, form, features, and whole organization of the human species,—multiplied by the mixture of nations, tribes, and families by conquests, migrations, and intermarriages.

The truth is, that if caloric be the organizing principle throughout nature, it must determine all the various degrees and modes of action, on which every diversity in the structure of plants and animals depends,—that as all the organs are formed by the nutritive process, the rapidity of which is in proportion to the amount of respiration, they are more fully developed in warm than in cold blooded animals, modified, however, by climate, or external temperature, nature of the surrounding medium, and the various circumstances which tend to augment the growth of some one or more organs, and to suppress that of others, as shewn by the numerous diversities of form, size, intelligence, &c. among animals belonging to the same genus and species.

Moreover, it has been ascertained by the researches of Lamarck, St. Hilaire, and other eminent physiologists of France, whose views have been adopted by Dr. Grant, that all the animals enumerated by naturalists (amounting to about

557,600 species,) have been formed after one and the same primitive type or model,—the lower orders differing from the highest chiefly by defect,—in other words, *that all the animals which inhabit the earth are, in reality, but one animal*, as maintained by Aristotle. The unity of organization has been still further traced by physiologists, who have found that in plants, the primitive tissues from which all the others are evolved, consist of nucleated cells, essentially analogous to those that constitute the elementary tissue of the ovum in all animals. (See Owen's Lectures on Reproduction, in the Lancet of 1841.)

And that there has been a gradually ascending progress of organization, would appear from the recent discoveries of geologists, who have found that the oldest sedimentary formations are filled with animals of the lowest class and most simple structure, which becomes more and more complex, until we arrive at the newer tertiary deposits, which abound with the fossil remains of the higher, or warm blooded species. Yet there is no historical proof that fishes have ever been transformed into reptiles, nor the latter into birds and mammalia. Nor is it probable, even if such were the fact, that it will ever be demonstrated otherwise than by analogy,—owing to the enormous periods of time, and perhaps the great geological changes, requisite to bring about corresponding changes of organization. In the present

imperfect state of our knowledge, it must therefore remain a problem, whether the higher orders have arisen by imperceptible degrees from a very simple state during the long course of innumerable ages.

It would doubtless be interesting to know whether, if all the plants and animals that now inhabit the earth were destroyed, similar orders, tribes, and families would gradually arise, in obedience to existing laws,—whether the higher orders began their existence in a very simple state, and gradually advanced from one stage of developement to another, as the recent discoveries in geology would seem to indicate,—why it is that among all the higher animals, nearly an equal number of the two sexes were produced, —whether the organizing principle is both male and female, as supposed by the ancient Hindoos and Egyptians, among whom it was represented by the *phallus* and a *triangle*, or generative organs of the two sexes. In all these things there is a profundity of wisdom before which we must bow with humility and pious adoration.

But I must now examine briefly the influence of climate on the duration of human life. From the researches of M. Moreau de Jonnés, published in the Revue Encyclopedique for 1833, we are enabled to compare the annual mortality of different countries in Europe, as in the following table, constructed from various statistical reports.

Great Britain from	1800	to 1804	1	in 47
Germany proper	1825	.. 1828	1	.. 45
Sweden and Denmark	1821	.. 1825	1	.. 45
Russia in Europe	1826	.. ——	1	.. 44
Kingdom of Poland	1829	.. ——	1	.. 44
Austria	1825	.. 1830	1	.. 40
Prussia	1821	.. 1826	1	.. 39
Holland	1827	.. 1828	1	.. 40
France	1825	.. 1827	1	.. 39·5
Switzerland	1827	.. 1828	1	.. 40
Spain	1801	.. 1826	1	.. 40
Portugal	1815	.. 1819	1	.. 40
Italy	1822	.. 1828	1	.. 30
Greece	1828	.. ——	1	.. 30
Turkey in Europe	1828	.. ——	1	.. 30

Thus we perceive, that in the temperate and colder latitudes of Europe, life is longer than in the warm climates of Italy, Greece, and Turkey, where the temperature of summer approximates that of the tropics; and longer in the equable climate of Great Britain, than in any other part of Europe. For example, it is stated by Mr. Farr, that the annual mortality of England and Wales, exclusive of still born infants, is 2·17 per cent.; while in Sweden it is 2·46, in France 2·52, and in Prussia 2·80. (Third Report of the Registrar General, p. 101.)

We also learn from the Second Report of the marriages, births, diseases, and mortality of England and Wales, that out of a population of 15,666,800 in 1838-9, there were 103 deaths at the age of 100 and upwards; and 140 per 1000 at the age of 70 and upwards. It is much to be

regretted, that these exceedingly valuable reports have not yet embraced Scotland and Ireland. Nor do they represent as they ought, the whole number of living individuals who have arrived at 100 years of age and upwards.

But it is stated by Dr. Copland in a note to Richerand's Physiology, that according to authentic returns, the ratio of centenarians in England was ·34 for every 20,000, in a population of 12,218,500 in the year 1821,—which would give 207 individuals then alive, who were 100 years old and upwards, or one for every 59,000. He also states, that in Scotland when the population was 2,135,300, the ratio of centenarians was 1·903 for every 20,000,—which would give 203, or one for every 10,484. And he says that in 1811, according to the bills of mortality in Russia, the whole number of deaths was 828,561, of which 947 occurred at the age of 100 and upwards,—fifty-one at 120, —twenty-one at 125,—seven at 130,—one at 135,—and one at 140. But there is reason to doubt the accuracy of this report; for according to Sir John Sinclair, the number of deaths throughout the empire, at the age of 100 and upwards, was only 436 in the year 1801. (Code of Health, vol. i. p. 119.)

The superiority of Great Britain over all other parts of Europe, in health and longevity, would appear from various considerations. Passing over the account of Galour M'Crain of the island of

Jura, who is said to have died in the reign of Charles I. at the age of 180, it is tolerably well established, that during the sixteenth and seventeenth centuries, Francis Conciest of Yorkshire, lived to the age of 150,—Thomas Parr of Shropshire, to 152,—and Henry Jenkins to 169 :—that in Scotland, Mr. Lawrence died at the age of 140, —Margaret Patton at 138,—and John Mount at 136 :—that in Ireland, Colonel Winslow died at the age of 146,—the Countess of Desmond at 140, —and a very large number in all parts of the United Kingdom, at 120 and upwards.

According to Mr. Finlayson, between 1813 and 1830, 290,309 individuals died at the age of 80 and upwards, out of 3,938,496, buried in England and Wales,—making 73 per 1000 ; whereas according to the tables of mortality in Prussia, the number of deaths from 1820 to 1834, at the age of 81 and upwards, was 207,599, out of 5,457,209, —making the ratio only 38·7 per 1000. (American Almanack for 1839.)

But if we are to credit the census taken in 1830, the number of centenarians in a white population of 10,845,729 in the United States, was 531, or one for every 20,425, and larger than the ratio in England, or perhaps any other part of the world excepting Scotland. What is still more remarkable, the number of slaves who had arrived at the age of 100 and upwards, was 1379 in a population of 2,010,436, or in the ratio of one

for every 1457. But as it is known that the ages of negro slaves are often uncertain, it is probable that in the present case they have been exaggerated, and must therefore be received with caution. This opinion is corroborated by the fact, that from 1830 to 1840, the increase of slaves in the United States was 476,777, or about 2·32 per cent. annually; whereas that of the white population was 3,343,489, (including a large proportion of emigrants from Europe,) or at the rate of about three per cent. annually. I have not before me the free black population of 1830; but it was 386,235 in 1840; and the number of centenarians among them in 1830, is represented as 741. (American Almanack for 1832-40.)

As for the rest, life is longer in both the middle and southern states, if we except Mississippi, Louisiana, and Florida, than in New England and other states north of lat. 40°.

Dr. Bisset Hawkins states on the authority of Ulpianus, that from the time of Servius Hostilius to that of Justinian, embracing about 1000 years, the mean duration of life among the free citizens of Rome was thirty years, which corresponds exactly with the present state of Italy, Greece, and European Turkey. But there is reason to believe that among the ancients, life was longer in those countries than among the moderns, especially in Greece. For Democritus is said to have died at the age of 108, Hippocrates at 104, Xenophon of Colophonia at 102, Xenophilus at

106; while Solon, Thales, Pittacus, and other sages, lived to the age of 100 and upwards. We are also informed by Lord Bacon, that during the reign of Vespasian, in the year 76, when the ages of the Roman people were registered, it was found that in the country between the river Po and the base of the Appenines, there were 124 individuals who had arrived at 100 years and upwards,—fifty-seven of whom were 110; four who were 130, and three, 140,—that in the hilly country around Placentia, there were six individuals aged 110; four who were 120; one woman 132; and one man, Marcus Aponius of Rimini, 150. (Life and Death.)

Bacon also enumerates several individuals who had arrived at the age of 100 and upwards in the city of Rome,—among whom were Orbilius, Metellus, Clodia, Terrentia the wife of Cicero, Luceia, and Galeria,—while Statilia lived to the age of 99, and Livia, the wife of Augustus, to 90. But, although the clergy of Europe as a class are long livers, Bacon says that among 241 Popes of Rome before his time, only five had arrived at the age of 80.

It is therefore probable, that during the high and palmy days of that great city, when supplied with an abundance of pure water, public baths, (at about a farthing for the poor,) and admirable sewers for carrying off filth, it was more healthy than during the reign of the Popes. The marshy districts around were also drained by Julius Cæsar

and his successor Augustus, by which the country was rendered more salubrious than at present. Nor was the eternal city polluted by the effluvia from grave yards,—like London and many other modern cities.

Thus we perceive, that after making all due allowance for the influence of civilization, industry, and the arts, on the mean duration of human life, it is greater in the temperate latitudes of Europe, than in either the north or south. And M. Quetelet has shown that in all parts of Europe, it is considerably greater in the country than in cities or large towns, in which it varies from 22 to 40·8 years in the middle and higher latitudes; but from eighteen to thirty-six years in the south of Europe,—and that in Belgium the proportion is 46·9 in the country, to 36·9 in the towns. (Treatise on Man, p. 28.)

The difference is still greater in England and Wales, where according to the Second Report of the Registrar General, the mean duration of life is fifty years in the country districts, and thirty-seven in the large towns. And the diseases chiefly incident to children, are twice as fatal in towns as in the country, as shown by the following table contained in the Third Report:

Deaths in 1,000,000 children living in the

	Country Districts.	Town Districts.
By Hydrocephalus ..	419	1071
Convulsions	942	2586
Pneumonia	995	2028

From scarlatina, measles, croup, small pox, and hooping cough, the difference was about the same, or in the average ratio of 1999 to 4014.

We also learn from the Third Report, that in England and Wales, the number of deaths in 1839-40, was 350,101,—of which 141,747 occurred under the age of five years, or in the proportion of 404 per 1000. From which it follows, that if we estimate the whole population of Europe at 230,000,000,* and the average annual mortality of individuals at all ages as one to forty, the number of deaths must be 5,750,000; and 2,323,000 before arriving at the age of five years. This enormous waste of life is owing greatly to the exposure of tender infants to cold and vicissitudes of temperature, at an age when the power of generating heat is so small, that they often become chilled even during summer, if not sufficiently covered, or if suffered to remain in their wet clothes.

As a proof of what has just been observed, M. Quetelet has shewn, that the mortality of infants is from 20 to 30 per cent. greater during winter than summer in Belgium,—that the maximum takes place at the end of winter, and the minimum about the middle of summer. We also learn from the Reports of the Registrar General, that among

* Of this number, 20,000,000 are paupers, or about 8·70 per cent. of the whole. In wealthy England it is 10 per cent. and in Ireland 33 per cent. of the whole population; while in France it is about 4 per cent.

aged people, and all individuals of feeble constitution, the mortality is from 30 to 50 per cent. greater during winter than summer,—that whenever the mean temperature in London falls below 50·5°, the mortality increases progressively,—that cold destroys a certain number of persons rapidly, and produces in others maladies which prove fatal in a month or six weeks,—so that the effects of a low temperature go on accumulating, and continue to be felt for thirty or forty days after the extremes have passed away. (Third Report, p. 108. Letter of Mr. Farr.)

The truth is, that the healthy growth of all young animals is retarded by cold, which is the great enemy of infants, old people, and all individuals whose power of obtaining caloric from the atmosphere by respiration is imperfect. There is reason to believe, that nearly all infants are born with a sound organization, and therefore might be reared to maturity, if always maintained at an agreeable temperature, supplied with suitable nourishment, pure air, and allowed plenty of moderate exercise. Owing to improvements in wealth, science, diet, clothing, habitations, &c. the mean duration of life has augmented from 20 to 30 per cent. in the middle latitudes of Europe, within the last 100 years; and the mortality of infants has diminished nearly 100 per cent. in the same time; for it has been estimated by statisticians of high repute, that between the years 1730 and 1750, it was about 740 per 1000

under six years of age. There cannot therefore be a rational doubt, that the general diffusion of sound practical knowledge of the animal economy among the people, would augment the average duration of life at least 50 per cent.

In regard to the mean duration of human life in the warm and tropical portions of Asia, Africa, and America, our information is exceedingly imperfect. But from all the best accounts I have been able to collect from books of travels, there is reason to believe, that in southern Asia, northern Africa, and central America, it does not exceed thirty years. For the Hindoos, Arabs, Egyptians, and southern Chinese, are said to be old at fifty, and rarely live beyond seventy years, if we except the Brahmins and the wealthier classes in general, who avoid the noxious influence of a burning sun, and resort to frequent ablutions with cold water—by which health is preserved, and life often protracted to eighty, or even to one hundred years in some cases, especially in the extra tropical portions of India, China, and Africa. It is seldom, however, that man arrives at the age of one hundred, even in the north of China, where life is longer than in the southern provinces. For we are informed by Sir John Sinclair, that when in the year 1784, the Emperor Kien Long ordered all the centenarians in his dominions to be numbered, only four could be found. (Code of Health, vol. i. p. 89.)

In the temperate climate of south Africa, the

mean duration of life among Europeans has been found nearly the same as in England; while it is said that the Caffres also, frequently arrive at the age of one hundred and upwards. Such, however, is not the case with either natives or foreigners in climates of perpetual summer, if we except a few small islands, which are exempt from extremes of temperature, and the impure air arising from putrefaction, combustion, and the respiration of animals. For example, life is longer in Bermuda, Barbadoes, and some other small islands, than in the same latitudes of America; while in Madeira and St. Helena, the average is said to be from forty-eight and a half to fifty years. From the facts collected by M. Moreau de Jonnés, as presented in the following table, we may form a general, though imperfect notion, in regard to the influence of a tropical climate on the mean duration of life among natives and foreigners. (See Quetelet on Man, pp. 27, 45.)

Batavia, 1805	Natives	40 years
..	Chinese	29
..	Slaves	13
..	Europeans	11
Bombay, 1815	Europeans	18·5*

* It is stated by R. D. Thomson in a recent work on Digestion, that among the Mahometans and Moguls of Calcutta, the mean value of life is thirty-six years; among the English twenty-eight years; the Armenians twenty-five; the Hindoos sixteen; and the native Christians fourteen,—making an average of nearly twenty-four years.

Bombay, 1815 ..	..	Mussulmans	17·5 years
.. .. ..	..	Parsees ..	24
Havannah ..	..	—— ..	33
Guadaloupe, 1811 to 1824		Whites ..	23·5
.. .. ..	..	Free Blacks	35
Martinique, 1815	..	Whites ..	24
.. .. ..	..	Free Blacks	33
Grenada	..	Slaves ..	22
St. Lucia	..	Slaves ..	20
Mean of the whole		..	24·5

Nor would the general result be materially different, if the Europeans were omitted in the estimate. We also learn from the sixth edition of Dr. J. Johnson's work on the Diseases of Tropical Climates, that the average annual mortality of the British troops in Bengal varied from 76·40 to 90·69 per 1000, from 1790 till the year 1810. According to the reports of Major Tulloch, it was 78·5 per 1000 among the white troops serving in the West Indies, from 1817 until 1836, or above five times greater than in the United Kingdom, where it was only 15·3 per 1000, and nearly the same in British America; whereas on the western coast of Africa, it varied from 483 to 668·5 per 1000. But he states, that among the black troops of Sierra Leone, including the slaves liberated by the English cruizers and settled there, it was only 30 per 1000, and about the same as the average annual mortality of the whole slave population throughout the British West Indies. He adds, however, that the mean duration of life among

the negroes of all ages does not exceed twenty-three years;* and that the annual number of births is not equal to the number of deaths.

Such facts exhibit in a very striking manner the fatal influence of tropical climates on Europeans, compared with the negro race. But why is the mortality of the whites so much greater in central Africa than in the East and West Indies? And why so much greater in all hot countries than among the natives? The rationale of the latter problem has been already given, when treating of the manner in which the developement of the chest, and the quantity of respiration are modified by external temperature, and will be further explained hereafter. The truth is, it is much easier to counteract the influence of external cold, by suitable clothing, habitations, artificial combustion, and a liberal supply of animal or oily food, than it is to avoid the debilitating tendency of a burning climate, and the noxious exhalations which it inevitably engenders, wherever there is vegetable and animal matter in a state of decay.

The greater mortality of tropical Africa than of the West Indies, must also be sought in the

* It is therefore not true, as maintained by Dr. Prichard and others, that the mean duration of life is about the same in all climates. Solomon tells us that fourscore was an extreme age in Judea. But we have seen that in Europe and the United States, it is frequently twenty, and sometimes fifty or sixty years longer. And Dr. Smith, who resided some time in Peru, informs us, that at Lima, the mean duration of life does not exceed twenty years.

vast difference between their climates. For although the mean annual temperature is nearly the same, it rises 20° higher during the heat of the day in central Africa, while it often descends to 60° at night, and sometimes to 50°, or even to 42° in the morning before sun rise,—making a diurnal range of from 50° to 70°; whereas in the West India islands it is only from 10° to 20°. Besides, owing to the vast bodies of alluvial lands, which are converted into swamps or morasses, by periodical inundations of the rivers in tropical Africa, a much larger amount of malaria is generated, than in islands of moderate size and a milder temperature.

Corresponding with this state of things, we learn from the travels of Adanson, Mungo Park, Winterbottom, Denham, Clapperton, and others, that the negroes on the Senegal, Gambia, and Niger, like those of Fezzan, Soudan, and other portions of central Africa, are generally a feeble, indolent, and phlegmatic race, who seldom live beyond sixty years,—who are grey, wrinkled, and decrepid with age at forty-five; while in health, strength, beauty, and intelligence, they are greatly inferior to the natives of the elevated plains of ancient Ethiopia and Abyssinia, or those of north and south Africa. But when removed to the milder climate of St. Domingo, and other West India islands, it is said by Collins and others, that in two or three generations, they improve greatly in all the endowments of body and mind.

As a proof of this, some of the black creoles of Hayti have been distinguished for courage, ability, information, and patriotism. We have also seen, that in the temperate climate of the United States, the increase of the negro population is nearly the same as that of the whites, notwithstanding the number of emigrants added annually to the latter.

It is therefore not true, as supposed by Dr. Prichard, that negroes are under the same disability to thrive and multiply in cold or temperate climates, as Europeans within the tropics. Nor is it true, as maintained by Dr. Caldwell, that " the negro is most healthy, long lived, and attains the highest perfection of his nature in his native country." On the contrary, there is but little reason to hope from the history of the past, that he will ever rise much above the state of barbarism, in the tropical portions of his native country. Why then should men calling themselves philanthropists, be so anxious to remove the black population of the United States, (where they multiply faster, and live longer, than almost any other people in the world,) to the western coast of Africa, where the mean duration of life is not much above twenty years, as among the colonized blacks of Sierra Leone and Liberia? It is a wicked and reckless expenditure of life and money.

It is said by Collins in his work on the treat-

ment of Slaves, that the creole women of the West Indies are more fruitful than the natives of Africa, among whom abortions are frequent. It is therefore not surprising, that the population of tropical Africa has always been sparse. The women are also unfruitful in the north of Asia, Europe, and America, where seldom more than three births are produced from one marriage ; and where the mean duration of life is short. For example, it has been computed that in Iceland, (the climate of which is moderate compared with that of Asia or America in the same latitudes,) the annual mortality was one in thirty, from 1825 to 1831. (Bibliothèque Universelle, Oct. 1833, p. 177.)

That moderately warm climates are more favourable to fecundity than such as are cold, has been established by the researches of Quetelet, who has shown that from the 40th to the 50th degree of latitude in Europe, 100 marriages give 475 births ; while from lat. 50° to 67°, the number is 430 ; and that in Portugal, it is 510, but only 362 in Sweden,—and greater in the south than in the north of France, in the ratio of 503 to 464. Perhaps there is no part of the world where the population increases so rapidly as in Ireland,*—especially when we consider the multitudes that

* Such is the delightful uniformity of temperature in the Green Isle, that at Cork, the mean of winter is about 43°, and that of summer 61°. When this beautiful country shall have thrown off the shackles of superstition, and obtained its political rights, it

emigrate annually to other countries; for according to Professor Rau, it doubles every 28·6 years; in England, every 42·3 years; in Spain, every 41·9 years; in Prussia on the Rhine, every 52·33 years; in Austria, every 53·6 years; in France, every 110·3 years; in Sweden, every 118; and according to M. Ch. Dupin, every 66 years in Russia. (Quetelet, Op. Cit. p. 51.)

It may be received as a fundamental axiom, that whatever is most delightful to the unperverted instincts of mankind, is most favourable to health, beauty, longevity, the developement of all the higher faculties, and the perfection of human nature,—such for example, as a medium temperature, pure air and water, simple but nourishing food, moderate exercise of the physical, intellectual, and moral faculties, especially of the domestic and social affections, and tranquillity of mind, which is the fruit of a well spent life.* Nor is it less certain, that whatever excites painful or disagreeable sensations, is detrimental to sound

will advance in literature, science, and the arts, with a rapidity proportioned to the physical superiority of its inhabitants. From all the foregoing facts and observations, it is evident that the climate of Europe is superior to that of all the other quarters of the Globe, and that of the United States next,—if we except New Zealand and a few other small islands.

* But it is stated by Sir John Sinclair in his Code of Health, that after many years of research, he had not been able to find one case of an habitually wicked man who had arrived at a great age. The truth is, that the natural tendency to crime is in itself a fatal disease, and should be treated as such.

health and long life, whether it be excessive heat or cold, too much or too little nourishment, excessive study, immoderate indulgence of the passions, impure air, the depressing emotions, nauseous drugs, or intemperance in the use of spirituous liquors.

From the researches of Dr. Madden, contained in his work entitled "Infirmities of Genius," it would appear, that notwithstanding excessive intellectual exertion is a frequent cause of ill health and premature death, the mean duration of life among the learned and liberal professions, is about 46 years, if we deduct 30 per cent. for the mortality of infancy. For he found that by taking twenty individuals belonging to each of the professions devoted to science, literature, and the arts, in different parts of Europe, the average was as follows :—

Writers on Natural Philosophy	74·7	years.
Moral Philosophy	70·8	
Artists	70·6	
Law and Jurisprudence	69·7	
Medicine	68·4	
Revealed Religion	67·7	
Philology	66·1	
Musical Composers	64·4	
Novelists	62·8	
Natural Theology	62·7	
Dramatists	62·4	
Poets	57·2	
Average	66·5	years.

But according to the researches of Caspar, as

given by Quetelet, theologians live longer in Prussia than any other class; agriculturists next; and physicians the shortest period of all. More extended observations are required to furnish data for a sure induction.

According to the reports of Tulloch, life is longer among officers of the British army in the West Indies, than among privates, in the ratio of 7·8 per cent. to 4·2; while the mortality increases from the age of eighteen to forty and upwards. And we learn from the late report of Mr. Chadwick, on the sanatory condition of the labouring population in England and Wales, that the average value of life among the nobility and gentry, varies from forty to fifty-seven years,—among the trades people, from twenty-seven to forty-one—while among labourers and mechanics, it is from fifteen to twenty-five years,—that above 50 per cent. of all the children belonging to the labouring classes die under five years of age; whereas the ratio is only 25 per cent. among the gentry. The fatal influence of destitution would appear from the fact, that out of 12,313 individuals of all ages, in the English workhouses, 2552 deaths occurred in 1838, or about 20 per cent. of the whole. (Lancet, May 1, 1841.) But even in the hospitals and infirmaries of England, the mean annual mortality varies from 4 to 11 per cent. according to Porter's Progress of the Nation.

CHAPTER III.

Influence of Climate and Season in modifying the Diseases of Mankind.

" The time may come when, guided by yet undiscovered knowledge, new and more direct principles, the tendency to tubercular and other morbid formations, may be surely checked, chronic inflammations cured, and fever suspended in its first movements."

CONOLLY.

A COMPLETE history of the mode in which the diseases and mortality of the human race are modified by external temperature, regimen, clothing, habitations, employments, and the various modes of living, would afford more practical information in regard to the causes, prevention, and right method of treatment, than all the systems that have been invented within the last two thousand years; for it would enable us to reduce the heterogeneous and chaotic mass of facts that constitute the sum of Medical Literature, to the certainty of an exact science. And that such an important undertaking might be, to a great extent, accomplished in a short time, by the combined exertions of a few enlightened individuals, is manifest from what has been recently done in

Great Britain by the Reports of Major Tulloch, and those of the Registrar General, aided by the judicious researches of Mr. Farr and other statisticians.

The diseases of man are no less modified by climate and season, than the various mechanical, chemical, and physiological operations of our planet,—being as different in the tropical portions of Africa, India, South America, and the West Indies, from what they are in the temperate and higher latitudes, as are the botanical and zoological characters of those regions.

The following tables, constructed from the Reports of Tulloch, laid before both Houses of Parliament, exhibit the average annual ratio of mortality per 1000 mean strength of the British troops serving in different parts of the world, from 1817 to 1836, omitting epidemic cholera.

TABLE I.

	United Kingdom.	The Canadas.	Nova Scotia & New Brunsw.	Mediterranean Command.	West Indies.	Jamaica alone.	Sierra Leone.	Cape Coast Command.
Fevers	1·4	2·4	1·6	13·0	36·9	101·9	410·2	382·6
Eruptive Fevers	0·1	0·2	...	...	...	...	...	...
Diseases of the Stomach and Bowels	0·8	1·3	1·5	3·5	20·7	5·1	41·3	220·6
Diseases of the Liver.	0·4	0·2	0·2	0·8	1·8	1.0	6·0	14·3
Respiratory Organs	7·7	6·7	7·1	4·8	10·4	7·5	4·9	1·6
Diseases of the brain	0·7	1·2	1·3	1·0	3·7	2·6	4·3	1·6
Dropsies	0·3	0·4	0·5	0·6	2·1	1·2	4·3	3·2
All other diseases	2·7	1·6	1·1	1·5	2·9	2·0	12·0	44·4
Total	14·1	14·0	13·3	25·2	78·5	121·3	483·0	668·3

TABLE II.

Exhibiting the average annual ratio of Mortality per 1000 of Black Troops serving in the West Indies, Sierra Leone, and the South-east coast of Africa.

	West Indies.	Sierra Leone.	Cape of Good Hope.
From Fevers	4·6	2·4	0·7
Eruptive Fevers	2·5	6·9	...
Diseases of the stomach and bowels	7·4	5·3	4·8
Disease of the brain	0·9	1·1	0·5
Respiratory organs	16·5	6·3	3·9
Of the brain	2·2	1·6	...
Dropsies	2·1	0·3	...
All other diseases	3·8	6·2	1·0
Total	40·0	30·1	10·9

Thus we perceive, that in Great Britain, the Canadas, Nova Scotia, and New Brunswick, about one half of the mortality is from diseases of the respiratory organs; whereas in the warm climate of the Mediterranean, they form about $\frac{1}{5}$ of the whole,—in the West Indies nearly $\frac{1}{7}$,—and not $\frac{1}{100}$ part among the white troops in tropical Africa. We are also informed by Tulloch, that in the East Indies, where the mean annual mortality varies from seventy to ninety per 1000, nearly the whole was from fever, dysentery, cholera, diarrhæa, and disease of the liver:—that among 74,850 native troops serving in Madras, the mean annual ratio was only one per 1000 from all diseases of the lungs; and but 2·4 in the Mauritius and at St. Helena. We further learn from the last edition of Dr. James Johnson's work on the Diseases of Tropical Climates, that from 1827 to 1836, the proportion of deaths from diseases of the respiratory organs was $\frac{1}{11}$ of

the whole at Calcutta,—at Chinsurah $\frac{1}{16}$,—and at Berhampore $\frac{1}{20}$. In north Africa, the mortality from phthisis is still less, according to M. Guyon, a medical officer of the French army, who states that from 1838 to 1841, it was only $\frac{1}{40}$ of the whole among the Moors at Algiers, —among the Jews, $\frac{1}{37}$,— and about $\frac{1}{20}$ among Europeans.

But why is it, that the mortality from diseases of the lungs is so much greater among negroes of the West Indies, than among Europeans? And why are the latter so much more liable to fevers when removed to tropical climates, than the natives? The solution of these queries must be sought in the radical difference of organization of men and other animals in cold or temperate, and in hot climates. For example, we have seen that owing to the high temperature of tropical Africa, for the greater part of the year, during the heat of the day, respiration is proportionally diminished, and the lungs exercised less, than in colder climates, by which the size of the thorax is accommodated to the wants of the system ; so that when removed to the West Indies, where the maximum temperature is from 10° to 20° lower, the natives of Africa are unable to obtain caloric from the atmosphere by respiration, as fast as it is abstracted by the surrounding media, especially in the high lands, or during the prevalence of northerly winds, and early in the morning when the air is damp.

The consequence is, that under such circumstances, they are often found shivering with cold; but never complain of the most intense heat of the sun, which is no less delightful to their feelings than conducive to health :—that during winter when northerly winds prevail, and the air is much cooler than at any other season, they are extremely liable to catarrh, influenza, pneumonia, pleurisy, and other diseases of the lungs, including rheumatism, eruptive fevers, dysentery, diarrhea, colic, and tenanus,—all of which are brought on by exposure to cold damp air, a shower of rain, and often by sleeping in damp clothes, by which the circulation through the lungs and general system is greatly diminished and perspiration checked, followed by congestion of the stomach and bowels, or of the pulmonary organs. Nor is it until several generations after his removal to a colder climate, that the thorax of the African is developed to the same extent as that of the European; so that, like the monkey, the lion, tiger, and leopard, he is proportionally subject to diseases of the lungs. On the other hand, as the lungs are more exercised in temperate and cold climates, the thorax is more highly developed among the whites, who therefore obtain a larger amount of caloric by respiration, *ceteris paribus*, by which they are enabled better to resist the influence of a low temperature. But for this very reason, when removed to the burning climate of

tropical Africa, India, and America, they receive caloric from the atmosphere by respiration faster than it is carried off, causing the temperature of the body to rise above the natural standard, and predisposing it to attacks of malignant fever.

According to an estimate of Mr. Farr, published in the second Report of the Registrar General, the mortality of England and Wales in 1838 was 342,559 in a population of 15,441,735, or in the ratio of 22·11 per thousand of all ages, and from all diseases,—which is 7·8 per cent. higher than among the British troops in the United Kingdom, from 1817 to 1836. The reason of this difference is, that the army is composed of men chiefly in the prime of life; whereas in the civil population of England and Wales, 130,695 of the deaths were of children under five years of age, or in the ratio of above forty per cent. of the whole mortality. And we have already seen that throughout the temperate and colder latitudes of Europe, a large proportion of the deaths among children are owing to the influence of cold, at a period when the power of maintaining the temperature at the natural standard is limited, and the whole organization extremely delicate.

In England and Wales, the mortality from all the diseases registered in 1838, was as follows, according to the classification of Mr. Farr. (See Second Report of the Registrar General, p. 100.)

Diseases of the Respiratory Organs.

Consumption	59,025	Influenza*	806
Pneumonia	17,999	Pleurisy	582
Asthma	5,745	Quinsey	432
Hooping cough	9,107	Laryngitis	99
Croup	4,463	Doubtful	2,568
Hydrothorax	2,306		
Bronchitis	2,067	Total	105,199

Diseases of the Nervous System.

Convulsions	26,047	Insanity...........	367
Hydrocephalus	7,672	Tetanus...........	129
Apoplexy.........	5,630	Delirium Tremens ..	182
Paralysis	4,975	Chorea............	24
Cephalitis	2,178	Doubtful	1,407
Epilepsy..........	1,093		
		Total	49,704

Fevers, epidemic and contagious Diseases.

Typhus...........	18,775	Erysipelas	1,203
Remittent Fever	182	Syphilis	159
Ague	44	Hydrophobia	24
Small Pox........	16,268	Thrush	1,090
Measles	6,514		
Scarletina	5,802	Total	50,061

Diseases of the Digestive Organs.

Gastritis and Enteritis	6,061	Tabes Mesenterica..	724
Diarrhea...........	2,482	Peritonitis.........	168
Dysentery	627	Ascites	63
Cholera.............	331	Intussception	233
Hepatitis	449	Stricture	111
Jaundice...........	841	Hematemesis	111
Hernia	507	Teething...........	4,404
Colic..............	619	Doubtful..........	3,978
Worms............	749		
		Total	22,463

* In the tables of Mr. Farr, influenza, croup, and hooping-cough, are classed as epidemics. But they also belong to the respiratory organs, as much as catarrh or pneumonia.

Diseases of uncertain Seat.

Dropsy	12,342	Debility	12,634
Inflammation	5,816	Atrophy	2,018
Abscess	1,478	Gout	207
Mortification	1,343	Malformations	166
Hemorrhage	1,218	Sudden deaths	3,012
Carcinoma	2,448	Scrophula	1,119
Tumor	373	Total	44,232

From diseases of the skin, urinary, sexual, and locomotive organs, the number of deaths were	7,436
Old age	35,564
Violent deaths	11,727
Intemperance	161
Starvation and want	167
Total	55,055

From the foregoing tables we perceive, that in England and Wales, a much larger number of individuals die from diseases of the respiratory organs than from any other class of maladies. And Mr. Farr has shown that in the metropolis, from January 1838, to June 1841, or three years and a half, the number was much greater during winter than any other season, as represented in the next table:—

	Winter.	*Spring.*	*Summer.*	*Autumn.*
Consumption	5,600	5,778	5,501	5,148
Pneumonia	3,326	2,454	1,827	3,600
Asthma	1,733	642	344	1,080
Hooping cough	1,674	1,208	644	787
Bronchitis	495	307	191	347
Hydrothorax	272	183	136	206
Pleurisy	70	62	39	51
Influenza	67	48	24	46

The greatest number died from consumption in spring, owing to the result of the previous winter's cold, as suggested by Mr. Farr. But this is not the only class of diseases that prove more extensively fatal during winter than any of the other seasons, as will be seen in the following table, the upper line of which represents the mortality of London from all diseases in 1838.*

	Winter.	*Spring.*	*Summer.*	*Autumn.*
	15,611	13,109	11,937	12,581
Apoplexy	299	241	201	246
Paralysis	234	181	135	187
Dropsy	501	427	375	465
Typhus	1,285	1,175	829	788
Old age	1,383	969	778	981
Sudden death	216	165	105	146
1838 to 1841.				
Diseases of child-bed	310	261	217	309
Diseases of the heart	739	556	571	698
Mortification	217	177	153	171
Ulcer	23	16	9	13
Phlegmon	9	2	3	1
Rheumatism	124	113	99	117
Insanity	73	45	35	42

(*Second Report of the Registrar General*, pp. 88, 90, 98, *and Third Report*, p. 105.)

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* Mr. Farr says, that the ratio of mortality in the different seasons has been about the same in England for the last one hundred and forty years, and is doubtless nearly so in all climates, in which the heat of summer is not sufficient to generate malignant epidemic fevers. And it is stated by Dr. Heberden, that from 1795, to 1799, the mortality of London was 13,406 in winter, 12,904 in spring, 9,678 in summer, and 10,226 in autumn.

From the 1st of January 1838 till the 1st of June 1841, the mortality of the metropolis from diseases of the digestive organs, was during winter, 1,982; in spring, 2,139; in summer, 2,978; and in autumn, 2,263.

The facts contained in the foregoing tables, especially the two last, are exceedingly instructive in a theoretical and practical point of view, as showing the influence of external temperature in modifying the general character of diseases, together with the true method of treating, or rather of preventing them. Should pathologists still assert, as they have long done, that phthisis depends on a *hereditary predisposition to the formation of tubercles*, and not on the influence of cold, nor vicissitudes of temperature, I answer, that in the middle and higher latitudes it destroys a much larger proportion of lives than any other disease,—that according to Dr. Granville, 38 per cent. of the mortality in St. Petersburg,* is from consumption. In the United States north of 40°, where the mean temperature of winter is from 25° to 34°, it has been estimated at 24 per cent. But in the middle latitudes of Europe, the mortality is about 20 per cent.; and varies from 12 to 15 per

* Other writers state that phthisis is less prevalent in Russia than in Britain and France. But in cold countries, far more attention is paid to warm clothing, and a regulated temperature within doors. And it is probable, however, that the disease is less prevalent in climates which are cold and dry, *ceteris paribus*, than in such as are cold and moist.

cent. in Italy, Spain, Portugal, Greece, the Ionian Islands, and the southern states of North America; while within the tropical portions of Asia, Africa, and other parts of the world, it forms a very small proportion of the whole, as we have already seen.

Should it be urged, that a large proportion of the deaths in the West Indies are from phthisis, this apparent exception to the general law, is partly explained by Sir James Clark, in his late valuable Treatise on Climate. For he states that it was formerly the custom to draught seamen, labouring under chronic diseases of the lungs, into ships going to the West Indies. He further informs us, on the authority of Ferguson, Musgrave, M'Arthur, Melville, Arnold, and other respectable medical writers, who had long resided there, that the climate is highly favourable to individuals *predisposed* to the tuberculous diathesis; but that, like all other hot countries, it hastens death in advanced stages of the disease. Yet he adds, that in the case of Dr. Heinekin, who remained several years in the mild climate of Madeira, (the mean annual temperature of which is 68·6°), after extensive ulceration of the lungs, and nearly the total loss of one lobe, his health always improved during summer, and declined in winter.

I have also frequently observed, that persons of small chest and delicate constitution, are af-

flicted with cold extremities and general chilliness, even during summer in England, while labouring under asthma or incipient phthisis; and that in some cases, the chemical function of the lungs was so far diminished, that it was difficult to maintain the temperature of the body at the normal standard, even before a fire that was oppressive to persons in good health. There cannot therefore be a doubt, that the temperature most favourable to individuals of weak lungs, is one from 65° to 70°, or even 75°, according to the more or less advanced stage of the disease; and that breathing an atmosphere below 50°, inevitably tends to aggravate all the symptoms. At the same time, we must admit with Sir James Clark, that many individuals are predisposed to this fatal malady by impure air, an impoverished diet, a sedentary life, the depressing emotions, excessive medication, (especially the use of mercury,) chronic disease from any cause, or whatever diminishes the natural vigour of the constitution. (Op. Cit. pp. 47—306, 3rd edition.)

Yet it is evident from all the foregoing facts and observations, that the tuberculous diathesis, as well as all inflammatory affections of the lungs, are generated chiefly by the depressing influence of external cold, and might be prevented in nine cases out of ten, by keeping the system at the natural standard, and maintaining a free circulation through the lungs, skin, and extremities.

Nor would it be very difficult for intelligent individuals in good circumstances, to regulate the temperature of their own private residences during the colder months, so as to obtain all the advantages of an artificial warm climate, if we except exercise in the open air. But as the same advantages might be secured in a far more effectual and economical manner, by the establishment of a large Sanatorium for the reception of patients labouring under chronic affections of the lungs, it is greatly to be desired that such an institution should be founded in some healthy place near London, with intelligent superintendents to regulate the temperature of the rooms, the diet, clothing, exercise, amusements, &c. of the inmates, who would in many respects be better off than in a foreign clime.

The manner in which diseases are produced by the influence of external cold, or by anything which reduces the temperature of the body below the natural standard, has never been satisfactorily explained. Nor is this very surprising when we reflect, that Physiologists have never yet ascertained the specific office of animal heat in circulation, sanguification, secretion, nutrition, sensation, and muscular motion. For if our pathology and methods of treatment are still imperfect, it is because the fundamental problems of physiology remain unresolved. Why then is it that catarrh, influenza, croup, hooping

cough, pneumonia, bronchitis, pleurisy, and phthisis, are so much more prevalent in the higher latitudes during winter than summer, and at all seasons than in tropical and warm climates ?

I answer, because the pulmonary air cells and schneiderian membrane, present an extensive surface to the atmosphere ; and that in cold climates, they are exposed to the paralyzing influence of a low temperature, more constantly than any other part of the body. The consequence is, that as animal heat is the immediate cause of all vital action, the chemical function of the lungs, sanguification, and circulation, are diminished, constituting the first link in the chain of the morbid phenomena, which are essentially the same in all cases, modified, however, by the condition of the system, the nature of the part more immediately affected, and the greater or less intensity of the exciting cause.

If the exposure is slight, or of short duration, and the lungs are sound, the result is what we denominate a common cold, which presents in a mitigated form all the essential conditions of fever. It is generally brought on by sitting in a cold room, exposure to damp or cold night air, a shower of rain, getting the feet wet, and often by sitting in a current of air when fatigued by exercise. The first effect of which is, that the capillary vessels of the lungs and schneiderian membrane are weakened, the circulation through

them diminished, and respiration of course impeded, attended with a sensation of chilliness,* which is increased by the slightest current of air. In this enfeebled condition of the capillaries, the lungs, lining membrane of the throat and nostrils, become congested with blood, when effusion of serum takes place, attended with coughing, sneezing, and a thickening of the membranes,—by which the bronchi, trachea, and nostrils, are more or less obstructed, the free inspiration of vital air impeded, the arterialization of the blood and its circulation throughout the body diminished, and all the secretions deranged.

* Dr. Edwards relates the case of a vigorous young man, who fell into the river Seine when it was full of floating ice, and with difficulty escaped by swimming; after which he continued chilly for three days, even before a warm fire. In this case, the circulation through the lungs was so far paralyzed by the immersion, that respiration was diminished. A similar case was related to me of a mechanic, who, after fatiguing himself by over-exertion, imprudently bathed in the river Wye, in the month of April, until he became chilled, which produced torpor and congestion of the lungs, that ended in what is called hepatization of their substance. And so far were the air cells thus obstructed, that he suffered a sensation of coldness throughout the following May and June, when he was removed in a state of extreme debility to St. Bartholomew's Hospital, where he soon afterwards expired. Now can any rational individual doubt, that an early application of the warm bath would have aroused the torpid circulation, restored the natural function of the lungs, and thus have prevented all the fatal symptoms that followed? Would not this delightful remedy be equally efficacious in the early stage of all diseases that are ushered in with chilliness? And if so, is it not the duty of every family to have a warm bath in the house?

Owing to the stoppage of perspiration, the skin is dry, tender to the touch, and no longer carries off two or three pounds of water per day, as in health. The consequence is, that it is retained in the blood, (unless carried off by the vicarious action of the kidneys,) by which its power of uniting with the solids and maintaining the secretions is diminished ; so that a portion of the caloric which is usually employed in these vital operations, and then carried off with the various excretions, is retained in the blood, causing a slight increase of temperature, termed catarrhal fever. But as the healthy activity of all the organs depends on the continual transfer of caloric, in combination with arterial blood to the solids, by which their composition and power are continually renewed; it is evident that whenever secretion and nutrition are diminished, there must be a corresponding reduction of sensorial and muscular power. Hence it is, that the acuteness of the senses and intellectual faculties is more or less impaired, while there is a general feeling of langour, stiffness and aching or soreness of the limbs, if not of the whole body, attended with a furred tongue, impaired appetite, and a feeling of drowsiness.

Such is the brief, but true history and theory of the most common disease that afflicts the human race and all the higher animals ; for it is the *roup* in poultry, the *distemper* among dogs, horses, and other mammalia,—nearly all the complaints

of which are brought by the immediate influence of external cold. If owing to a change of wind, the temperature is suddenly reduced 10° or 20° over a large extent of country, the disease becomes more violent, and assumes the character of a wide spreading epidemic, termed influenza, which prevails occasionally at all seasons, but is generally much milder and of shorter duration in summer; because at that season, the reduced temperature that brings it on, is soon followed by warm weather.* When it comes on with a cold northern or eastern wind, after the powers of life have been diminished by a hot summer, and the prevalence of a malarious atmosphere, it assumes the type of a more malignant fever, ushered in

* It has been often asserted by medical authors, that epidemic influenza is not brought on by cold, nor vicissitudes of temperature, because it sometimes appears during summer. But in temperate climates, the transitions from heat to cold are often greater and more sudden during summer than winter. Nor is it surprising that the disease should exist in the tropical portions of India and Africa, when we reflect that the diurnal temperature of those regions varies from 30° to 50°. Dr. Dieffenbach maintains, that epidemic influenza is generated in the middle latitudes of the northern hemisphere, by a *peculiar miasma*, originating in the northern portions of Europe, Asia, and America. He also states, that in Europe, it spreads from the north east to the south west, with the speed of the prevalent wind, and diminishes in violence with the distance from its origin. However this may be, it may be asserted with confidence, that in no climate nor season, is the imaginary *miasma* competent to produce the epidemic, without a reduction of temperature; and it is well known to be most prevalent when the fluctuations of temperature are greatest and most frequent.

with spasmodic shuddering, pains in the head, back, and limbs, loss of appetite, hot and dry skin, constipation, red urine, derangement of all the secretions, and a general prostration of strength.

If from any local cause, the membrane lining the trachea or larynx, is weaker than any other part of the respiratory apparatus, the same kind of exposure that induces catarrh in ordinary cases, brings on inflammation of the parts, with an effusion of lymph, by which the free admission of air into the lungs is obstructed, and suffocation produced, as in croup and laryngitis,—unless the debility and congestion of the capillaries be speedily removed by local depletion, warm fomentations to the throat, the frequent use of hot gargles, warm drinks, the inhalation of steam, and whatever tends to equalize the circulation, restore the action of the lungs, and bring on perspiration.

If from any cause, the capillaries of the lungs, bronchi, or pleuræ, are in a weak state, the same exposure induces congestion and inflammation, followed by the effusion of serum, lymph, and sometimes red blood, by which respiration is impeded, and sanguification greatly diminished, as in pneumonia, bronchitis, and pleurisy.* If at

* We have seen that asthma is five times more fatal in England and Wales during winter than summer. In a very large majority of cases, respiration is so far diminished, owing to an obstructed state of the lungs, that the temperature of the body is

an early stage of their progress, the circulation through the lungs and general system can be restored by the inhalation of steam, the use of hot drinks, the application of dry heat to the chest and other parts of the body, all immediate danger is removed, and the disease rendered mild or of short duration. But if the congested state of the capillaries be suffered to remain for some time, the nutritive properties of the blood and its coagulating power, are so far impaired, that the local symptoms are followed by general fever, loss of appetite, pain in the head, back, and limbs, prostration of strength, delirium, coma, and subsultus tendinum, as in typhoid pneumonia, and what has been called *bilious* pleurisy.

If the chest be small, the lungs imperfect, and the general powers of the constitution en-

generally below the natural standard, and sometimes, from 10° to 20°, according to the observations of Dr. Bree; attended with a spasmodic condition of the respiratory muscles, fits of partial suffocation, a deranged condition of the blood, and of all the secretions, followed by thirst, high coloured urine, and other symptoms of fever, when the chemical function of the lungs is not too far diminished to bring on reaction. But although exposure to cold is the common predisposing and exciting cause of the disease, like phthisis it is aggravated by the rarefied air of heated rooms, and by hot sultry weather, which also diminish respiration, and often produce syncope. We have also seen that hooping cough is nearly three times more fatal during winter than summer,—which shows, that, like all diseases of the respiratory organs, it is brought on chiefly by the influence of external cold, and should be treated by regulating the temperature of the patient.

feebled by impure air or impoverished diet, want of exercise, and the depressing emotions, exposure to a cold atmosphere, a shower of rain, or to damp night air, with thin clothing, after the body has been fatigued with exertion, or weakened by sitting in a crowded assembly, the capillaries of the lungs are so far debilitated, that the free circulation of blood through them is greatly obstructed, respiration, and sanguification are diminished, attended with cold extremities, derangement of all the secretions, and general loss of strength, owing to the impoverished condition of the blood, which is no longer capable of duly nourishing the solids. In this state, the cohesion of the pulmonary capillaries is so far overcome, that an effusion takes place into the air cells, of serum, albumen, and lymph, which are gradually converted into tubercles,* that vary from the size of

* It was supposed by Hippocrates, that all diseases of the throat and lungs were owing to the excess of *phlegm*, and that its effusion into the air cells gave origin to the formation of tubercles, which on putrifying became pus. Within the last hundred years, it has been the fashion to regard tubercles as the cause of phthisis. But if it be true, that the tubercular and scrophulous diathesis is comparatively rare in tropical and warm climates, like all cutaneous and pulmonary diseases, they must be regarded as secondary effects arising from exposure to cold, which is also the cause of excess in the quantity of phlegm. According to Dr. Alison, above one third of the deaths in Edinburgh under fifteen years of age, are from scrophulous diseases, which are well known to be still more prevalent in the north of Europe, and more so in all the higher latitudes during winter than summer.

a pin's head to that of a pea, or even of a small walnut,—after which they dissolve into a semi fluid pus, that is discharged from the lungs by coughing.

Such are the leading symptoms of phthisis, which, in almost every case, may be traced to inflammation of the lungs and bronchi, or to the influence of repeated colds that have been neglected, and which in nineteen cases out of twenty might have been avoided. But if suffered to run on till ulceration of the lungs is fully established, all rational hopes of a permanent cure must be given up. The only successful method of treating this fatal malady is, to prevent its actual formation, by avoiding all the predisposing and exciting causes, or to arrest its progress at an early stage, by placing the patient in a genial atmosphere, and supplying whatever is calculated to restore the languid circulation of the lungs. For it will be proved hereafter, that all congestions, inflammations, and effusions, depend on debility in the capillaries of the part affected. And if there be anything in nature that deserves the name of *panacea* or *universal remedy*, it must be that agent or principle, which maintains all the organs of the animal economy in a healthy state, renews the composition of lost parts, and that of the whole body when wasted by illness, from whatever cause. This doctrine was in part recognized by Hippocrates, Erasistratus, Herodicus, Asclepia-

des, and other ancient physicians, who treated inflammation of the lungs, pleuræ, throat, and other parts of the body, by the inhalation of steam, by hot gargles, external fomentations, the warm bath and friction, the application of heated iron, or bags of hot sand, ointments, cataplasms, cerecloth, and wrapping the part with woollens.

Sir James Clark informs us, that in Paris, the mortality from consumption is greater among females than males, in the ratio of 13 or 14 to 10; and that in Berlin the difference is still greater between girls and boys. But at Hamburgh, Geneva, and New York, there is a slight excess among males. According to the Report of the Registrar General, the mortality was 31,090 throughout England and Wales in the year 1837-8, among females; and 27,935 among males. Mr. Farr rightly ascribes the difference partly to the sedentary life of females, and partly to compression of the chest by costume; both of which diminish respiration, and impair the vital properties of the blood, which deposits tuberculous matter with an unnatural facility. (Second Report of the Reg. General, p. 73.) The evil is doubtless aggravated by exposure of the neck, shoulders, and arms, the want of sufficiently warm clothing in winter, (especially of flannel drawers when the constitution is delicate,) thick stockings, boots, and shoes.

According to Lombard and Papavoine, above

25 per cent. of all who die in Paris, from birth to puberty, are affected with tuberculous disease, which is most prevalent during the third, fourth, fifth, and sixth years, *but is extremely rare in the first year of infancy.* We are also informed by Sir James Clark, that in all the numerous examinations of Velpeau and Breschet, they found no tubercles in the fœtal state; and that M. Guizot discovered none while dissecting 400 new born infants,—but that after the second year, they were found by M. Guersent, to be extremely prevalent in the Hôpital des Enfans Malades, in Paris. (Cyclop. of Pract. Medicine, No. 22, pp. 307-8.) From which it would appear, that the disease is seldom hereditary, but acquired after birth, by exposure to the various predisposing and exciting causes that bring it on at all periods of life.

It is frightful to contemplate the aggregate amount of disease, suffering, and mortality, that arise in temperate climates, from ignorance or inattention in regard to the danger of simple exposure to cold, currents of air, and getting wet, especially when the body is fatigued by over-exertion; and the irreparable loss to the public of individuals in the prime of life, distinguished for ability and usefulness.* We have seen that,

* The last illness of General Washington was brought on by exposure to a very slight rain, which produced inflammation of the larynx, that very soon destroyed life by suffocation. That of General Harrison was also induced by exposure to a cold misty

from diseases of the nervous system, old age, and sudden deaths, the mortality is nearly double in winter what it is in summer in the city of London, —while from pneumonia, asthma, hooping-cough, croup, bronchitis, influenza, pleurisy, quinsey, laryngitis, and hydrothorax, the difference has

rain, during a long walk before breakfast, in the month of March, —soon after which, he was attacked with a chill that lasted several hours, causing torpor, congestion, and inflammation of the thoracic and abdominal organs, followed by general fever, that terminated fatally in a few days. The melancholy death of Robert Burns in the meridian of life, was caused by exposure to cold damp night air, after a fit of intemperance; and by sea bathing, recommended by his medical adviser, when reduced to a state of great debility. And that of the celebrated William Pinckney, of Maryland, originated from a cold brought on by sitting up until four o'clock in the morning, in a cold room reading the Pirate, just then published. The greatest poet of the nineteenth century also lost his life in the full vigour of his faculties, from exposure to a heavy shower of rain on the 10th of April, 1824, and by remaining for some time in an open boat with his wet clothes on. Soon after this, he was attacked with shivering, languor, pains in the head, back, and limbs, followed by a low fever,—for which he was bled twenty ounces on the 17th, and the operation repeated twice the next day, followed by faintness, delirium, coma, cold sweats, and death on the 19th. (Moore's Life of Byron.)

Now I appeal to the common sense of all intelligent men, whether immediate recourse to the warm bath, surrounding the patients with bottles of hot water, or bags of hot salt, would not have prevented the chill, and consequently the fever or inflammation, that carried off these illustrious individuals? and whether, in the case of General Washington, the immediate application of hot fomentations to the throat, with the free use of hot gargles, would not have overcome the torpor of the capillaries lining the larynx, and thus have arrested the disease in embryo?

been much greater; and nearly 25 per cent. greater from all diseases.

If, then, it be true, that in a population of 15,441,735 in England and Wales, the annual mortality is 105,199 from diseases of the respiratory organs, it is fair to conclude, that in the whole of Europe, with a population of 230,000,000, the annual mortality is 1,566,907 from maladies of the same class. For if they be less fatal in Italy, Greece, Spain, and Portugal, than in Great Britain, the case is otherwise in Russia, Sweden, Norway, and Denmark, where it was estimated by the Chevalier Edelcrantz, that 75 per cent. of all the diseases are owing to the immediate agency of cold.*

But although a large majority of diseases are brought on by the influence of cold, the long continuance of an elevated temperature is still

* It was observed during and after the disastrous retreat of the French from Moscow, that paralysis, deafness, loss of vision, and apoplexy, were frequent effects of exposure to intense cold, which is so well known to be the cause of rheumatism, that patients affected with it have been called weather gauges. It is truly observed by Bright and Addison, in their recent work on the Practice of Medicine, that apoplectic and hemiplegic patients are occasionally affected with pains in the limbs or side, resembling the rheumatic and neuralgic affections arising from exposure to a current of cold air :—that the first distinguishable effect of such exposure is often a paralysis,—that in other cases, lumbago terminates in paraplegia,—that exposure of the face sometimes causes neuralgia, and at other times mere paralysis without pain. (p. 576.) Nor is there anything surprising in all this, when we reflect, that a great reduction of temperature in any part of the

more fatal to the human race, by generating fever, dysentery, diarrhea, hepatitis, gastritis, and enteritis,—all of which belong to the same class, and are modified effects of the same morbific states of the atmosphere. We have seen that malignant fever, and diseases of the abdominal viscera, are far more prevalent and fatal in the tropical portions of Africa, Asia, and the West Indies, than in the warm climates of southern Europe or the United States, where they are also more common and violent than in the temperate and higher latitudes. According to Humboldt, whose statement is confirmed by the Reports of Tulloch, the yellow fever of the West Indies is never produced at an elevation of 2,500 feet above the level of the sea. And Dr. Caldwell asserts, from his own observations, that it never made its appearance in the United States, without a mean temperature of 80°, for the period of at least a month. (Malaria and Temperament, p. 63.)

The most deadly forms of remitting fever that

body is attended with the loss of sensation and motion. It has also been shown by Tulloch's Reports, that cutaneous diseases are far more prevalent in cold than in hot climates. And the fact has been unknowingly established by the celebrated quack Priesnitz, who causes his patients to remain from fifteen minutes to an hour, or more, three times a day, sitting in a bath at 60°, which in a few weeks causes the skin to be covered with eruptions, boils, or abcesses, that sometimes discharge daily several glasses of matter, which is regarded as a critical evacuation of bad humours. (Hydropathy, by Claridge, pp. 118, 125, 196.)

ever afflicted mankind, have prevailed in tropical Africa, where the temperature is higher during the heat of the day, than in any other part of the globe, and where the atmosphere is filled with putrid effluvia from the decomposition of vegetable matter—both of which diminish respiration, sanguification, secretion, nutrition, and all the forces of life. Many travellers relate, that when trading caravans are overtaken by the hot simoom from the Great Desert, (which operates like a furnace or heated air bath,) it causes excessive langour, prostration of strength, loss of appetite, nausea, fainting, and sometimes sudden death.* Under such circumstances, the process of respiration is nearly arrested, and the temperature of the solids is raised so nearly to an equilibrium with that of the arterial blood, that the transition of caloric from one to the other, on which the process of nutrition depends, is nearly suspended, and all the energies of life are proportionally diminished.

When the system has been exposed for several

* To avoid its fatal influence, the Arabs are in the habit of lying down, digging holes in the ground, and applying their nostrils to the fresh earth. The East India Papers also state, that during the month of June, 1842, the mercury stood at 110° in the shade at Jellalabad, (in lat. 26°,) and that the British soldiers dug holes under their tents, by which they obtained a temperature of 90°. No wonder the beasts of the forest in Africa and southern India, retire during the heat of the day to the thickest shades they can find, or to pools of water, where they lie panting until the cool of the evening comes on.

hours of each day, for several weeks, and even months, to a temperature varying from 120° to 130° in the sun, and from 95° to 100°, and sometimes 10° or 12° higher in the shade, the powers of life are so far diminished, that when the atmosphere is suddenly reduced to 70°, as during the hurricanes of the rainy season; or to 50°, and sometimes to 42° just before sun-rise, as in tropical Africa and India, chilliness comes on, with a general torpor of all the organs, obstructed circulation, a livid hue of the surface and extremities, and a deranged condition of the blood, which being no longer duly renovated by respiration, is unfit to combine with the solids and maintain the several functions of life.* In some cases, the cold stage is ushered in with stupor, apoplexy, and all the symptoms of cerebral congestion, followed by malignant fever, dysentery, cholera, hepatitis, dropsy, apoplexy, or paralysis.

Corresponding with the general fact that all maladies belonging to the febrile genus, are far more prevalent in tropical and warm climates than in the middle and higher latitudes, they

* Hence the prevalence of liver disease in hot climates and malarious districts; for the venous blood of the bowels has to circulate through the whole capillary system of the liver, before it gets into the general circulation, to be renovated in the lungs. The consequence of which is, that when respiration, and the power of the general circulation, are very much diminished by the united influence of a high temperature and an impure atmosphere, the liver is more liable to congestion than any other part of the body.

are most fatal during the alternations of sultry heat and floods of rain, that prevail during summer and autumn, in almost every part of the torrid zone, where at that season, they often assume the form of typhus; while it is well known, that in India and in central Africa, the cool winds of the dry season are highly refreshing, and bring with them health, strength, and a delightful flow of spirits, but often produce coughs and other catarrhal affections.

It is therefore obvious, that the surest method of preventing the diseases of hot climates, is to maintain the temperature of the body at the natural standard, by resorting to frequent ablutions in cold water, (as practised by the Brahmins and Egyptian priests,) a light vegetable diet, with pure water, sweetened with sugar, or slightly acidulated; by avoiding exposure to the hot sun, the use of all spirituous liquors, animal food, fatigue of body or mind, especially, the chilling influence of damp night air, cold rains, &c. With such precautions, I should not fear to encounter the most fatal climate of India or Africa.* But

* That health might be preserved in the most sickly parts of the tropical zone, would appear from an experiment performed by Captain Murray, and related by Mr. George Combe, in the Constitution of Man. After remaining two years on the coast of Labrador and Newfoundland, with a crew of one hundred and fifty men, Captain Murray left Plymouth on the 24th of December, 1823, for Tampico, Curaçoa, Vera Cruz, and the West India islands, where the Valorous remained eighteen months without losing a

unfortunately for the greater part of mankind, their ignorance in regard to the simplest laws of life and health, has ever been a most fruitful source of disease, suffering, and premature death, even in the most favourable climates.

For example, there is no part of the world more favourable to health and longevity than England. But owing to the former ignorance, indolence, poverty, and wretched state of the inhabitants, their neglect of agriculture, the filthy condition of the streets and houses in large towns, the country was visited by famine and pestilence forty-four times from the year 1069 to 1392, or during the space of 323 years. And Mr. Farr informs us, that London was desolated by the plague twenty-four times from 1407 till 1665,—that during the last one, 68,596 individuals were

man, or having one on the sick list. This extraordinary result was achieved by keeping the vessel dry and clean, which was accomplished by frequent washing and scrubbing of the decks, which were thoroughly dried by means of Brodie stoves, kept burning in the cock pit and between the lower decks. The bedding of the men was also kept dry, and they were supplied with two extra pairs of flannel shirts and drawers, which were shifted every Sunday. Nor did he ever suffer the watch to turn into their berths with wet clothes on. In addition to all this, the men were not allowed to labour in the hot sun, and had their allowance of cocoa before leaving the ship in the morning, with a supply of fresh meat and vegetables, whenever they could be obtained. But they were never permitted to go on shore in the hot sun, nor where spirits were to be obtained. It is impossible to estimate too highly the conduct of this enlightened officer, who richly deserves a knighthood for the valuable lesson he has taught mankind.

swept off by the epidemic, and 97,902 during the same year from all diseases, when the whole population did not exceed 165,000. (Medical Almanac, p. 178.)

Thus we perceive that during the frightful reign of ignorance and superstition, when pestilence and famine were regarded as judgments inflicted on mankind for their sins, the mortality was far greater in the temperate climate of England, as in many other parts of Europe, than in the sickly portions of tropical Africa, India, and South America. For in no part of the world has it equalled that of London in 1665, where, as we have just seen, nearly two-thirds of the inhabitants perished. And during the prevalence of the black death, the sweating sickness, and most of the above plagues, the number of deaths varied from thirteen to thirty per cent. of the whole population. But thanks to the progress of knowledge, and the various improvements to which it has led, such fatal epidemics have almost entirely disappeared throughout the temperate latitudes of the civilized world.

It is stated by M. Lafere, that in 1835, the mortality from plague was ten per cent. of the whole population in Cairo, and thirty-three per cent. in Alexandria. But there is reason to believe, that when those cities shall be kept as clean, well watered and ventilated, as London is at present, or as Memphis and Thebes were during the epoch of the Pharaohs, the plague will cease there also,

as the yellow fever has done in New York, Philadelphia, Baltimore, and will shortly do in New Orleans. All other things, however, being equal, the mortality from fever is greater in tropical than in warm climates, where it is more prevalent and fatal than in the middle and higher latitudes.* Nor is it less certain, that nearly all the plagues which have desolated Europe, from those of Athens and Rome, down to the 17th century, including the late epidemic cholera, prevailed chiefly during the latter part of summer and beginning of autumn, or until arrested by frost, which puts an end to all epidemic fevers, if we except typhus,—a disease that prevails at all seasons among the poor, ill fed, and badly clothed inhabitants of large towns, and filthy or crowded dwellings.

Again; the continued form of fever predominates in tropical and warm climates, but remittents and intermittents in the higher latitudes, where they prevail chiefly during warm weather, and are arrested by frost. Nor can there be a rational doubt, that all the varieties of fever are different forms of one and the same disease,

* Dr. Archibald Smith informs us, that the black cattle of Peru and other elevated portions of South America, cannot endure the climate of the low and burning plains near the coast, where, like the human species, they die in great numbers from fever, which is more malignant when they are fat, than lean. Ashmun states in his Diary, that at Liberia, in tropical Africa, "every scratch or puncture becomes an ulcer; and that months are often required to dry it up."

modified by climate and season, states of the atmosphere, modes of living, &c. The fevers which prevail in central Africa, Egypt, the East and West Indies, are not more different from each other, than the climates of those regions. The truth is, that there are no two countries in the world in which the climate is precisely the same; nor is it probable that any two seasons are precisely alike, even in the same countries.* Hence the endless varieties of fever, which are never the same in any two places or seasons.

* It is true, that the mean annual temperature of the same place is nearly the same for long periods of time,—or at least within a very few degrees of a uniform average. At Chiswick, in the vicinity of London, the mean temperature of ten years, (1826—35,) was 50·5°; while that of 1838 was only 47·6°. But the mean of January 1838 was 28°; whereas the average of the same month was 36° during the preceding ten years, and the minimum 10°. In 1838, however, it fell 4·5° below 0°, or 14° lower than it had done for ten years. At the apartments of the Royal Society, the mean of the year 1838 was 48·9°, or 1·3° higher than at Chiswick. According to Mr. Luke Howard, the mean temperature of London from 1797 to 1819, was 50·65°, while at Tottenham Green, four miles north from town, it was 48·8°, making the difference 1·85°. In the third Report of the Registrar General, it is stated by Mr. Farr, that the mean of January, February, and March, 1838, was 36·3°; and 4·6° lower than during the same period in 1840; while the spring of 1841 was 4·3° warmer than that of 1839. And the summer of 1842 has been 4·75° warmer than that of 1841—making a very large increase in the products of the soil throughout the United Kingdom. In the United States, the mean annual temperature of the year at Germantown, near Philadelphia, was 49·6° in 1821, and 54·2° in 1825, making the difference 4·6°. And it is still greater during different seasons, especially when one winter is compared with others.

It has been generally supposed, that the plague of Egypt, Smyrna, and Constantinople, is a radically different disease from the yellow fever of Malta, Spain, the West Indies, and the southern United States. But it has been satisfactorily ascertained by accurate observations within the last forty years, that, like yellow fever, the plague at one time assumes the form of typhus, at another time that of malignant remitting, or intermitting fever, according to the locality, season of the year, state of the weather, &c.—that it is not more contagious than any other form of malignant fevers,—that inguinal tumors are not essential to its existence, being absent in many cases, and sometimes present in yellow fever.

That epidemic cholera is owing to the same morbific constitution of the atmosphere which produces malignant fever, would also appear from the fact, that during its prevalence, it was far more fatal in tropical and warm climates, than in the temperate and higher latitudes. For example, it was far more destructive in India, Arabia, Syria, and Persia, than in the colder parts of Asia; and more so in the south than in the north of Europe, where it prevailed chiefly during summer and autumn. And it was far more fatal in New Orleans, where the temperature of summer is tropical, than in New York, Pensylvania, Maryland, or any of the middle and northern states, where it also prevailed chiefly during the fever season. In the year 1832, there were 3,200

deaths from cholera in London; 2,330 of which occurred in July, August, and September,—while in 1833, nearly the whole mortality occurred in August and September. In the course of July and August, it swept off 15,000 individuals in the city of Mexico, the population of which was 200,000; and 8,253 in Havanna, out of 65,000 inhabitants. (Lancet of Jan. 6th, 1835.)

A still more decisive proof that cholera, dysentery, and other diseases of the digestive organs, belong to the same genus as fever is, that they are convertible into each other, according to the state of the weather. As an example of this, epidemic cholera made its appearance in New Orleans in the summer of 1833, during a succession of cold and heavy rains,—after which the weather became hot and dry, when the disease assumed the form of malignant yellow fever, which continued with great violence until arrested by frost.* It is also well known, that in Balti-

* The fact is, that blue cholera, like the worst forms of typhus and dysentery, is in most cases an undeveloped fever, or one in which the cold stage remains throughout the disease: for in all the milder cases, there was more or less fever, which often presented typhoid symptoms. What Sydenham said of Dysentery, may be said of cholera,—that it is "a fever turned inwards,"—or one in which respiration is so far diminished, that there is not animal heat enough obtained to produce reaction. And I have frequently observed the same thing in the worst forms of yellow fever, which, as before stated, is sometimes attended with buboes,—regarded by many as peculiar to the oriental plague. But the essential character is the same in both, which are brought on by modifications of the same causes, and require the same

more and many others parts of the United States, as in most other parts of the world, intermittent fever will make its appearance in June; and sometimes assume the character of malignant remittent, or yellow fever, as the season advances, until there comes on a succession of cold rains, when it suddenly changes to dysentery, which continues until the commencement of frost, or a change of weather from wet to dry.

In his treatise on the epidemic cholera of India, Mr. Orton says, that in Bengal, Bombay, and the Carnatic, it prevailed chiefly during the south west monsoons, and declined during the dry season,—that like fever it followed the course of large rivers, and was most fatal in the low, moist, filthy, and ill ventilated portions of large cities, (p. 169.) It was also ushered in at St. Petersburg, Warsaw, and Vienna, by rainy weather, according to M. Londe. And Dr. Jannechen says, that its fatality in Moscow was in proportion to the hygrometric state of the atmosphere. Moreover, like the black death of the fourteenth century, the sweating sickness of the fifteenth, the plague of the seventeenth, and in fact all other great epidemics, the

general treatment. Like typhus, they often terminate with diarrhea and colliquative sweats, or transudation of the watery parts of the blood through the capillaries of the skin, stomach, and bowels, as in epidemic cholera,—while it is worthy of notice, that the colour of the skin which comes on a short time before death in yellow fever, is owing to the effusion of serum through the coats of the cutaneous capillaries into the cellular tissue of the skin.

cholera was preceded by a remarkable change in the general character of the seasons. We are informed by Dr. Foster, that the winter before it made its appearance in India, was one of unusual severity all over the northern hemisphere of the old world,—that snow covered the earth over a large portion of northern Africa, and nearly the whole of southern Europe. (Lancet, October 22nd, 1831.)

Dr. Brown further informs us, in an article contained in the fourth volume of the Cyclopedia of Practical Medicine, that in the summer of 1817, cholera broke out in the Delta of the Ganges, after an unusual disturbance of the seasons, with respect to vicissitudes of heat and moisture,—that it commenced in the district of Nuddea, where the whole year had been rainy, (with a succession of thunder storms,) and the country flooded with water.

Dr. Billing maintains with Mr. Orton, that cholera is essentially a febrile disease, whether intermittent, remittent, or continued,—that it is a modification of the black death, the sweating sickness, the plague described by Sydenham, and subsequently by Frank,—that whoever has had much experience in ague, has seen all the modifications of cholera,—the cold stage with spasms, corresponding with the convulsions of cholera,—the nausea and diarrhea of ague, corresponding with the vomiting and purging of cholera,—the blueness of the skin, low pulse, and

shrunken features of ague, corresponding with the general stagnation of the blood and prostration of strength in the *blue* cholera,—finally, the passage of ague into continued fever, a frequent termination of cholera. And so general is the depression of temperature in typhus, that Dr. Billing objects to the hot stage as essential to its existence. (Principles of Medicine, pp. 216, 228, 230.)

Like the black death, the sweating sickness of 1485, (described by Dr. Caius,) the algid fever of Alibert, the cold plague of the United States, and the lowest forms of malignant typhus, epidemic cholera was ushered in with impeded respiration, coldness of the breath, surface, and extremities, which felt like the back of a frog. And the temperature under the tongue was often 20° below the natural standard. As might naturally be supposed, the power of the heart was greatly reduced, and the circulation through the lungs so much diminished, that the blood was no longer renovated by respiration, but became dark and grumous, even in the arteries,—causing a livid hue of the skin, with a suspension of the nutritive process, and of all the secretions.

Owing to the cessation or great diminution of the formative process, the cohesive power of the capillaries is so far weakened, that the serous or watery portion of the blood exudes through their coats into the stomach and bowels, producing

what has been called the rice water discharges ;* and when it percolates the cutaneous capillaries, causing the cold sweat, which marks the latter stages of most diseases. Like the hemorrhage from the gums, nose, ears, and anus, during the latter stages of typhus and other malignant diseases, or the vibices of spotted fever, such effusions always indicate a broken down condition of the solids, and a disorganized condition of the fluids. The truth is, that epidemic cholera affords an

* The rice water discharges were found to consist chiefly of albumen, serum, and salts of the blood, which contained a much larger proportion of red particles, than in health,—not because richer in organic matter, but because deprived of its more fluid constituents ; for it was so far disorganized that it refused to coagulate, and presented the appearance of a black grumous mass, like semi-fluid tar. On the supposition of Dr. Stevens, that the worst symptoms of cholera were owing to a loss of the saline constituents of the blood; and owing to the extreme coldness of the patient, the plan was adopted at one time by some physicians in England, of injecting into the veins muriate and carbonate of soda, in the proportion of two drachms of the former and two scruples of the latter, to about four pounds of water, at the temperature of from 108° to 110°. Dr. Pereira informs us, that a medical gentleman injected eight pounds of this solution into the veins of a patient in half an hour,—in another case, thirty-one pounds in the course of fifty-three hours,—and in another case, forty pounds in twenty hours,—that the process was followed at first by a revival of the pulse, (as might be supposed from the warmth imparted by so much water at the temperature above stated,) but soon after by death. Nor is this very surprising, after the experiments of Magendie, who found that the injection of an ounce of carbonate of soda into the veins of a healthy dog, induced langour, coma, fever, convulsions, and death, in from two to three days.

example of all the varieties of fever in their most malignant forms; for they are all ushered in by diminished respiration, a reduction of temperature, stagnation of the blood, with a loss of its vital properties, prostration of strength, insensibility, and derangement of all the functions.

The primary and leading symptom of cholera is a great and sudden reduction of temperature. According to Mr. Orton, and many other writers on the disease, "the generation of animal heat almost entirely ceased," the breath, tongue, and whole body, became cold, the blood viscid and dark coloured, even in the arteries, the surface livid, and all the secretions suspended. It is therefore evident, that the first step to be taken in the treatment, is to raise the temperature of the patient to the natural standard, by which the heart would be enabled to restore the circulation through the lungs, and thus renew the vital properties of the blood, on which all the healthy functions of the body depend. For it has been often observed, as in cases of suspended animation, from remaining some minutes under water, that blood cannot be obtained until the circulation is revived by placing the patient in a hot bath, or by the application of dry heat.

Now if it be true, that the first link in the chain of morbid phenomena which constitute epidemic cholera, be a uniform and great reduction of temperature, what can be the use of the lancet, eme-

tics, purgatives, and the injection of saline solutions, without restoring the natural temperature and circulation of the body? It is true that respiration is diminished by a uniform high temperature of the atmosphere. But it is still more diminished during the languid state of the circulation that attends the cold stage of all diseases, and should be restored by artificial warmth, which promotes the flow of blood through the lungs, the chemical function of which is augmented by the warm bath, in all cases of feeble circulation and coldness of the extremities.

During the existence of cholera in Germany, the papers gave an account of two salt-boilers who were attacked with the disease, and given over as hopeless by the attending Physician. But the superintendent of the establishment observing that they were extremely cold, resolved on trying the efficacy of putting them in a bath as hot as the hand could bear. The consequence was, that a few minutes after he placed one of them in the bath, his skin changed from purple to a bright red colour, when he began to take deep inspirations, which increased in frequency as the circulation revived. He soon afterwards recovered his senses, and observed how very delightful his feelings were. The same plan was then pursued with the other patient, attended with similar results, and both speedily recovered without any other remedies. All the phenomena of

physiology demonstrate, the salt-boiler employed the very best possible remedy, by availing himself of the agent or principle on which all the operations of life and health depend. It is also stated by Dr. Caius, that the most effectual method of treating the sweating sickness, which in several respects resembled the blue cholera, was to ply the patient with hot drinks, and cover him well with blankets, until the circulation was restored, when the cold sweats diminished, and the powers of life gradually rose.

It has been shown by M. Quetelet, that in plague, cholera, and epidemic fevers of all descriptions, medical treatment is generally of little avail. And it must be admitted that we know very little in regard to the peculiar nature of the remote cause on which the specific character of each depends. Nor is it probable that a knowledge of what constitutes an epidemic state of the atmosphere, would enable us to prevent its occurrence, unless we could regulate all the meteorological changes and revolutions that make up the phenomena of climate and season. It has been repeated a thousand times, that the nature of malaria is a profound mystery. But if it be the result of vegetable and animal decomposition, it must consist of some one or more of the combinations of organic matter in the gaseous state, such as carbonic acid, carburetted hydrogen, phosphuretted hydrogen, ammonia, or some other gaseous

product capable of being subjected to chemical analysis. And it will be seen hereafter, that all the mephitic gases diminish the process of respiration, reduce the temperature of the body, and thus tend to produce a chill, by which nearly all diseases are ushered in,—in short, that their influence is to vitiate the nutritive properties of the blood, and diminish all the energies of life.

But although we may not know precisely whether malaria depends chiefly on the agency of carbonic acid and vicissitudes of temperature, or some other yet undiscovered effluvia, in conjunction with heat, cold, and moisture, we can clearly distinguish the manner in which they operate, and the effects they produce on respiration, sanguification, secretion, nutrition, and all the vital functions. Whether generated in large cities, confined dwellings, or marshy districts, its morbid influence is essentially the same, modified, however, in all cases, by climate and season, being always more concentrated and malignant where the temperature is highest, *ceteris paribus*. And whether cholera be contagious or not, like typhus, yellow fever, and plague, it is generated by foul air, bad diet, filth, cold, moisture, fatigue, and the depressing passions, where none of them before existed.

In the large towns of Great Britain, typhus fever is sometimes more fatal during winter than summer, because the want of sufficient clothing

and fuel among the poor, induces them to block up every chink and aperture by which the carbonic acid exhaled from the lungs of many individuals, occupying the same room, is prevented escaping, and fresh air from entering, until the air becomes exceedingly noxious. And it is certain, that during hot weather, fever is often produced by the exhalations of men in previous good health, when thickly crowded together in prisons, transport ships, barracks, workhouses, and the confined dwellings of large towns. At the same time, it is still more certain, that fever is often produced by cold and vicissitudes of temperature alone, without the influence of malaria, or any other cause, as might be exemplified by innumerable cases, which mark the progress of pneumonia, pleurisy, and other inflammatory affections, brought on by exposure to cold.

From the foregoing facts and observations, it must be evident, that the diseases of mankind obey the same laws which govern all the other phenomena of nature. If the vast and extremely complex science of meteorology were thoroughly understood in all its multifarious details, we should be able to comprehend why one season differs from another in temperature, direction of winds, and quantity of rain, in any given place; and to predict those now mysterious revolutions of the atmosphere which seem to return at certain periods, as shown by the myriads of insects that

appear in many parts of the world, at intervals of seventeen, thirty, or more years. We should then know why epidemics prevail over continents, and sometimes a whole hemisphere, for one, two, or more seasons, and then disappear, or assume a different type,—why the black death differed in some respects from the sweating sickness, and the blue cholera from both, in other respects. What medical authors term *an epidemic constitution of the atmosphere*, is a mere cloak for ignorance of the various physical changes that mark the course of nature. To refer it to the influence of comets, *telluric* emanations, and other occult causes, is no better than the idle dreams of astrology.

We are told by medical authors, that fever and many other forms of disease, are generated by *malaria*. But they have never yet informed us what malaria is, nor how it produces intermittent fever in one case, remittent fever in another case, typhus fever, yellow fever, plague, cholera, dysentery, diarrhea, &c. in other cases. This much, however, is certain, that it proceeds from the decomposition of dead organic matter, the principal results of which are carbonic acid and water, with very small proportions of carburetted hydrogen, sulphuretted hydrogen, and phosphuretted hydrogen. But it is still undecided whether malaria depends on a greater abundance than usual of carbonic acid, or of some other gaseous emanation.

That malaria is not carburetted hydrogen would appear from the fact, that in coal mines where it is evolved in large quantities, ague is a very rare disease, but is very prevalent in low, damp, and foggy situations, especially during autumn, when the debilitating heat of summer is succeeded by cold nights and mornings. From which it might naturally be inferred that *vicissitudes of temperature are essential to a malarious constitution of the atmosphere.* And notwithstanding the assertion of Dr. Caldwell, that carbonic acid does not exist in unusual quantities in malarious districts, *it is certain that of all the morbific exhalations from decaying vegetable and animal matter, it is by far the most abundant; and that when accumulated in large quantities, it is capable of producing the most fatal forms of fever.*

For example, it is recorded in several works of high authority, that in the year 1775, one hundred and forty-six British soldiers were shut up in a dungeon called the black hole of Calcutta, which was eighteen feet square, open to the west only by two small windows, that were strongly barred with iron, and from which they could receive but a small supply of fresh air,—that in the course of one hour, or at nine o'clock in the evening, respiration became difficult, followed by raging delirium, and before eleven o'clock, by the death of about fifty men. At six o'clock in the morning, only twenty-three remained alive; and what deserves our spe-

cial notice is, *that in the course of a few days, nearly the whole of this small remnant died from putrid fever, resembling the worst forms of typhus.* But I have already stated, that typhus and other malignant forms of fever, have prevailed to a frightful extent, in crowded ships, prisons, barracks, workhouses, hospitals, and the confined dwellings of the poor in large towns.*

Should it be objected, that the fevers generated in such places, may be owing to noxious effluvia arising from the decomposition of various species of filth, I answer that *carbonic acid is the principal result of all vegetable and animal decomposition, whether in open marshy districts, or in crowded and ill ventilated dwellings.* We are also informed by Dr. Perceval, that a gentleman's servant in Liverpool, after being exposed for some time to the fumes of

* Dr. James Johnson also informs us, that two men were suddenly attacked with rigors, faltering pulse, great debility, nausea, oppression of the precordia, twitching of the muscles, a muddy appearance of the eyes, dimness of sight, headache, and low fever, succeeded by clammy sweats, hemorrhage from the gums, petechiæ, a bubo in the right groin, and another in the axilla of one man, who died on the fourth day, and the other on the fifth day, after being exposed while in good health to the putrid effluvia from the grave of a man who had been buried three months, near the city of Canton, in China, and which they unknowingly opened when digging a grave for one of their comrades. (Trop. Climates, p. 70, 6th ed.) It is therefore evident that all the symptoms of plague and the most malignant typhus, may be generated immediately by carbonic acid and other gaseous animal effluvia, when sufficiently concentrated.

burning charcoal, while cleaning plate in a small room, the door and windows of which were closed, was seized with shivering, drowsiness, stupor, nausea, pains in the head, back, and limbs, followed by thirst, dry skin, and fever, that continued for two days, when he gradually returned to his former state of good health. It is therefore impossible to deny, that carbonic acid alone is capable of generating fever, which varies in its character according to the time of exposure, the amount inhaled in a given time, the constitution of the patient, &c.—that when greatly concentrated, as in the black hole of Calcutta, crowded ships, jails, barracks, and workhouses, it produces all the symptoms of malignant typhus, such as coma, delirium, subsultus tendinum, and a dissolved condition of the blood, especially in persons already predisposed by the depressing passions, want of suitable nourishment, clothing, and exercise.

It is maintained by Dr. Bancroft, Caldwell, and others, that if carbonic acid were the cause of fever, it ought to be produced in cases of exposure to the atmosphere of crowded assemblies, and all places in which it is more abundant than in the open air. To which I answer, that many individuals of delicate constitution are actually predisposed to catarrh, pneumonia, phthisis, rheumatism, and fever, by remaining for only two or three hours in crowded and ill ventilated churches,

in which respiration is seriously diminished, and all the functions of life impaired, as shown by the languor, drowsiness, headache, and even syncope, induced in some cases. Nor can there be a doubt, that such exposure for a sufficient length of time, would greatly impair the vital properties of the blood, and so far derange the nutritive process as to induce all the symptoms of malarious fever.

I therefore appeal to the candour of all enlightened minds, whether it is not more in the spirit of true science, to ascertain the influence of carbonic acid, and of all other gaseous emanations which are known to arise from the decomposition of dead matter, than to seek for the nature of malaria in some mysterious and hypothetical condition of the atmosphere about which nothing is known? And whether vicissitudes of temperature do not constitute a still more important condition of what is termed malaria, than even carbonic acid, or any other mephitic gas. For it is certain, that in hot climates and seasons, exposure to fatigue during the heat of the day, and to the cool damp air of night, are by far the most common exciting causes of fever, the malignity of which is in proportion to the elevation of temperature where it prevails, *ceteris paribus*.

CHAPTER IV.

On the Agency of External Temperature in producing Hybernation and suspended Animation.

" In the multitude of books there was no where comfort or knowledge, but vain promises, abuses, and many errors. The cup of sloth hath tainted the schools with drowsiness, every one being more willing to assent, than to search carefully. I therefore considered within myself, that the art of healing was a mere juggle." VAN HELMONT.

DR. ROGET maintains in a Treatise on Animal Physiology, contained in the Library of Useful Knowledge, that " Hybernation is a provision of nature to preserve animals from the effects of a temperature that would be fatal to them." And Dr. Marshall Hall observes in an article on Hybernation, contained in the Cyclopædia of Anatomy and Physiology, that " the lethargy of animals is not the effect of cold, but is a physiological condition of the system, which differs from ordinary sleep only in degree;" and that " the true spinal or excito-motory system of nerves," (to which he refers the irritability or contractility of the muscles,) " retains all its energies." What is still more remarkable, he maintains that " *the irritability of animals is inversely as the quantity of their respiration, being greater in reptiles*

and fishes than in mammalia, and least of all in birds; while in hybernating animals it augments as their respiration diminishes."

In accordance with the foregoing strange and unexplained doctrines, it is maintained by Dr. W. F. Edwards, in his excellent work on the Influence of Physical Agents on Life, translated by Hodgkin and Fisher, that "the degree most favourable to life is a cold temperature." (p. 89.) And he adds in another Treatise, contained in the Cyclopædia of Anatomy and Physiology, that "in cold blooded animals, the vitality of the nervous system is always greater than in such as are warm blooded,"—that among reptiles and fishes, "the maximum of vitality corresponds to the depth of winter, and the minimum to the height of summer." (vol. ii. p. 674.)

Dr. Edwards seems to have arrived at these conclusions, from finding that frogs, toads, and salamanders, were capable of living longer under aerated water reduced below the temperature of 50°, than when at 100° and upwards:—for example, that when frogs were confined under water of the Seine at 50°, they lived from 5h. 50m. to 6h. 15m.,—and that when kept under water cooled to 32°, they lived from 6h. 7m. to 8h. & 18m. But when the water was raised to the temperature of 72°, (that of the air being 68°,) they continued alive from 35m. to 1h. 10m. When raised to 90°, they died in from 12 to 32 minutes; and

when raised to 108°, they never lived above two minutes. He also found that frogs could live in a vessel containing 17½ pints of aerated water, when changed every day, from the 4th of December till the 25th of February; showing that they are really amphibious at temperatures from 32° to 51°. He further ascertained that fishes live much longer in water deprived of air, at temperatures below than above 50°. (Influence of Phys. Agents, p. 17.)

The above experiments prove only, that when the circulation of frogs and other batrachians is partially suspended by cold, they require less air to maintain a low degree of vitality, than when the circulation is increased by placing them in a higher temperature. As a proof of this, Dr. Edwards himself informs us, that frogs lived twice as long under water at 50° on the 23rd of November, as when immersed in water of the same temperature during summer,—showing that when the activity of their functions is greatly diminished by the coldness of approaching winter, there is air enough in water to support their feeble vitality for a long time; but that when their circulation, respiration, and general activity are augmented by the higher temperature of summer, they require more air than water contains; therefore die in a much shorter time, and, perhaps, in two minutes or less, when confined under water at 108°.

In like manner, it is evidently owing to the torpid state of the circulation in reptiles, fishes, worms, and zoophytes, that they live so much longer in vacuo and the mephitic gases, or when greatly mutilated, than warm blooded animals; and that even the latter require but little air to support a low degree of vitality, when reduced to a state of torpor by external cold. Hence it is, that frogs remain for weeks, and even months under water, (which contains only about 3 per cent. by volume of air, according to Humboldt,) during winter, or so long as the mean temperature of the ponds and marshes in which they reside is below 50°.

Dr. Edwards performed some experiments on frogs and salamanders, which led him to suppose that they are capable of living in aerated water at temperatures below 50° by *cutaneous respiration;* because when strangled by placing a ligature around the throat, and placed in a receiver containing atmospheric air, they remained alive from one to two hours; and when taken out of the vessel, it was found to contain a sensible quantity of carbonic acid. He further states, that when the heart of salamanders was removed by excision, they lived from twenty-four to twenty-six hours in the atmosphere, but only from eight to nine hours when immersed in cold water at the same temperature:—that when the lungs of frogs were extirpated, they lived from one to five days

in the air, but died in from eight to twelve hours when immersed in water at the same temperature. He therefore concluded, that air exerts a vivifying influence on the blood and nervous system, independent of the lungs and general circulation. But he seems to have overlooked the fact, that owing to the greater conducting power of water, it abstracts the vital heat from animals more rapidly than air. From all the foregoing facts and observations, it is obvious, that the *duration of life in animals after respiration has ceased, is inversely as the quantity of their life, and the general activity of their functions.*

In the first chapter of this book, it was shown that in birds and all the more active mammalia, respiration is augmented by cold. But we shall find that among insects, reptiles, and even the lower orders of warm blooded animals, it is diminished by a low temperature; and that whenever it falls below 52°, or the point at which the growth of plants is arrested, all the functions of life become languid, or entirely suspended. For example, it was found by Spallanzani, that bees and other insects consume three times more oxygen at 70° than at 36°; and similar results were obtained by Treviranus. Owing to the large extent of radiating surface, compared with the actual size of the body, whenever the surrounding air becomes cold, as on the approach of winter, they lose caloric more rapidly than it is gained by

respiration, notwithstanding the great activity of that function during summer.

It has been observed by Saizy and others, that in the bat, dormouse, hedgehog, marmot, and other warm blooded animals of the lower class, respiration is diminished by a low temperature, by which that of their own bodies is greatly reduced. And that this is owing to the imperfect developement of their lungs, would appear from the following experiments of Saizy, who found that when a marmot was surrounded by a freezing mixture at 14°, its temperature fell from 95° to 41°; and that of a bat from 93° to 57° in one hour, when placed in air reduced to 33·80°; but when a guinea pig was submitted to the same experiment as the last, it lost only 3°. (Récherchés Experimentales sur la Physique des Animaux Hybernans.)

In accordance with the above facts, it has been proved by the observations and experiments of Pallas, Spallanzani, Hunter, Jenner, Reeve, Prunelle, and others, that in the middle latitudes of Europe, hybernating animals become frozen at temperatures of 10, 14, and even 26° F., as observed by Dr. Jenner, in the case of a hedgehog, in the comparatively mild climate of England. Spallanzani also states, that in the still milder climate of Italy, life is so far diminished in the bat and dormouse, that digestion, circulation, secretion, and even *irritability*, appeared to have

ceased entirely,—that no change whatever could be observed on placing them *in vacuo*, or the mephitic gases; and that they no longer responded to the stimulus of electricity. What then must be the condition of such animals during winter in the higher latitudes of Asia and America, where the mercury falls from 40 to 70° lower than in England and Italy? How are the foregoing facts to be reconciled with the assertions of Marshall Hall, Dr. Edwards, and all those physiologists who regard "the lethargy of animals during winter as a condition of the system which differs from ordinary sleep only in degree?"

That hybernation is owing to cold alone, would appear from the fact, that neither in plants nor animals does it ever occur in temperate latitudes until the approach of winter, if we except the torpor of the tenrec, the serpent, and some other animals within the tropics, caused by excessive drought, and the evaporation of their fluids,—for the same reason that grass and many other succulent plants wither and die during summer in all parts of the world. And as vegetation may be kept up during winter by artificial warmth, so has it been found, that the dormouse, squirrel, and other hybernating animals, remain active throughout the year, when kept in a temperature above 65°, as in climates of perpetual summer. It has also been proved by the experiments of Spallanzani and Pallas, that hybernation may be

produced in the height of summer by artificial cold. Whenever the atmosphere falls below the point at which these animals are capable of maintaining their temperature at the normal standard, the circulation through the lungs is diminished, less carbon and hydrogen are given off, and less oxygen is consumed, than during the warmer months. But even in summer, respiration, circulation, secretion, nutrition, and their power of locomotion, are much less energetic, than in the higher mammalia.

It was at one time supposed by John Hunter, that animals might be wholly deprived of life, for indefinite periods of time, by the influence of cold, and be again restored by the gradual application of warmth. With a view of ascertaining the fact, he performed many experiments on the combs of cocks, the ears and feet of rabbits and other animals,—which showed that they might be completely frozen, and afterwards restored to a healthy state. As might naturally be supposed, the vitality of the blood was for the time destroyed, and the capillaries so far weakened, that when the circulation was restored, they were expanded by the *vis a tergo*, and tumefaction induced, as in all local inflammations. As the natural properties of the blood are in all such cases impaired, it cannot unite with the solids, until renovated in the lungs by respiration; so that the caloric usually employed in the process of nutrition, is given out in

the free state, causing an elevation of temperature, or local fever, which disappears as soon as a free circulation of blood is restored through the part by warm fomentations, poultices, &c.

But the experiments of Hunter are annually performed by nature on a grand scale, and in a far more instructive manner, in the middle and higher latitudes, where the whole vegetable world, and all the lower orders of animals, including, as we have seen, many species that are warm blooded, are reduced to a state of suspended animation, for months during winter, but rise to newness of life when "The flowers begin to appear on the earth, the time for the singing of birds is come, and the voice of the turtle is heard in the land."

Will it be said that a frozen animal is not dead, but retains a small remainder of vitality in a latent state? Where then is the evidence of this, when respiration, circulation, secretion, nutrition, and absorption, are suspended, and every sign of irritability extinguished? However this may be, it is not true that when the functions of life are once completely suspended, they cannot be again restored, as maintained by modern Physiologists. On the contrary, it is absolutely certain, that the lower species of animals may be, and have remained, in a frozen state for weeks and months, with *the aptitude to live, but without life.* It is stated by Isaac Walton, on the autho-

rity of Gesner, that some breams were placed in a pond, that became one *mass of solid ice the ensuing winter*; but that soon after it was melted by the warmth of spring, they were found swimming about in perfect health. (Complete Angler, p. 257.) Captain Franklin also states, that in the Arctic regions, fishes taken out of the sea, became often frozen throughout until brittle as ice, and were afterwards reanimated when placed before a fire. Dr. John Davy informs us further, that his brother Sir Humphrey kept leeches for several weeks in a congealed state, from which they revived in a warm room; but that when reduced to the same condition by freezing mixtures, and suddenly transferred to warm water, they all died soon afterwards, except one.

Why then, it may be asked, are there so few recoveries from death caused by cold, strangulation, and suffocation in mephitic gases? For it is stated by the managers of the Royal Humane Society of London, that life is rarely recovered after the individual has remained four minutes under water. But Dr. Edwards found that young puppies may be kept under water above 15 minutes, or reduced to a state of suspended animation by cold, and be restored to activity by fresh air and warmth,—that young rabbits immediately after birth, could sustain the want of air for 28 minutes; when 5 days old, for 16 minutes; when 10 days old, for $5\frac{1}{2}$ minutes; but when 15

days old, for only $2\frac{1}{2}$ minutes. Many other experiments might be adduced in support of the doctrine, that life may be suspended for a much longer time in very young animals, and be again restored, than at later periods; and longer in all classes, in proportion as their vitality is less.

It is also known, that the human subject may remain for many days in a state of partially suspended animation, and be recalled to activity by proper treatment, as in cases of trance,—that Elizabeth Woodcock of Impington, while returning from market at Cambridge, in a state of intoxication, was overwhelmed by drifts of snow, under which she remained for 8 days and nights, but died some months afterwards from a low congestive fever, induced by that long chill. And it is stated by Baron Larrey, that most of the soldiers who escaped death during the fatal retreat of Napoleon from Moscow, afterwards died of low fevers, attended with coma, delirium, hemorrhages, and subsultus tendinum; or were attacked with paralysis, deafness, impaired vision, neuralgia, rheumatism, dysentery, and diarrhœa. It is also related by M'Nish, that sheep have remained buried under banks of snow for six weeks, in the Highlands of Scotland, and for two months in Iceland,—which recovered when released from their paralyzing confinement.

It is therefore probable, that our power of restoring warm blooded animals, not excepting

man, from a state of suspended animation, is much greater than is generally supposed. At the same time, there is reason to believe, that this power is confined to cases in which there has been no serious disorganization,—that when the movements of life are suddenly arrested from any cause, the blood undergoes the process of coagulation, or is so far disorganized as to become unfit for nutrition,—for we have seen that when taken from a healthy sheep, and surrounded by a freezing mixture at 0°, it coagulated before congealing. Owing, however, to the gradual reduction of their temperature, circulation, &c. on the approach of winter, the blood of reptiles and hybernating animals does not coagulate; so that on the return of spring it recovers its fluidity, colour, and power of stimulating the heart and other organs, at the same time. I have shown that after blood has been frozen, its contractility, like that of the muscular fibre, may be restored by raising its temperature. But that its organization may be seriously deranged by congelation, would appear from the fact, that after eggs have been frozen and then thawed, they lose their transparency, and become opaque, (as may be seen by holding them up to the light,) and will not hatch.

In attempting to restore suspended animation, it is idle to rely on electricity, bleeding, injections of tobacco, and other equally useless or per-

nicious remedies. The managers of the Royal Humane Society have long since thrown aside the Galvanic battery as a mere toy,—and like sensible men, follow the indications of nature, by resorting to the warm bath, beds heated with hot water, inflation of the lungs with fresh air, and the application of bottles filled with hot water to the thorax, with a view of arousing the suspended action of the heart. Until the circulation is restored, what can be the use of the lancet, or even brandy, ammonia, and other stimulants? In short, we must rely chiefly on the great conservative principle of nature in the treatment of all maladies. And they who neglect her precepts, deserve not the name of Physicians.

There are many facts recorded in the scattered annals of natural history and physiology, tending to show, that even birds may be reduced to a state of suspended animation by cold, and afterwards restored by the gradual application of warmth. For it was found by Spallanzani, that on surrounding martins with ice, they lost all sensibility and power of motion, but revived when placed before the fire. And many other highly respectable authors assert, that swallows have been found during winter in the hollows of trees, in a state of complete lethargy, from which they were recovered in the same way. Although the smaller birds have great powers of obtaining caloric from the atmosphere by respiration when in a healthy

state and well nourished, many of them lose it still more rapidly in a very cold atmosphere,—owing to the large extent of radiating surface, compared with the diminutive size of their bodies. So true is this of young poultry, that they never thrive and grow well at temperatures below 65°, but pine away gradually, and die of the roup, or some influenzal disease. It is therefore probable, that the process of artificial incubation, and the rearing of poultry, cannot be carried on so well in the middle latitudes as in warm climates, like that of Egypt, where nearly 100,000,000 are thus produced annually.

It was maintained by John Hunter, that *animal temperature is an effect of the vital principle, which he supposed had the power of generating both heat and cold.* In support of his opinion that animal heat is generated by the *materia vitæ*, he observes that when a dormouse was exposed to the influence of a freezing mixture, "it defied the cold while the vigour of life lasted, but that when all signs of life were extinguished, it became frozen." (Phil. Trans. of the Royal Society, vol. lxvi.) But he might have said, that so long as a portion of its heat remained, it retained a certain amount of vitality; and that when deprived of heat, it became frozen or dead. He further maintains that temperature is the effect of vitality, because a longer time is required to congeal birds and mammalia, than reptiles and fishes, whose vitality is

much lower. But we have seen, that birds generate about sixteen, and mammalia above eight times more caloric in a given time, than the same weight of reptiles,—therefore must require a longer time to be reduced to the frozen state. In support of the above argument, he found that fresh eggs were a longer time in congealing, *ceteris paribus*, than after they have been deprived of life by being frozen. But it is known to those who deal in eggs, that fresh ones are warmer to the touch, than after they have been frozen or spoiled by long keeping, and may therefore be supposed to contain more caloric around their particles. For the same reason, fresh blood requires a longer time to congeal than after it has been once frozen, and then raised to its former temperature.

Hunter was further confirmed in his opinion that "life has the power of regulating animal temperature," because he found that on introducing the bulb of a thermometer into the urethra of a living penis, while immersed in water at 50°, it fell from 92 to 58°; but that in a dead penis it fell to 50°. He also found that when a living penis was immersed in water at 118°, with the bulb of a thermometer in the urethra, it rose only to $102\frac{1}{4}$°, and to 104° when applied to its surface, while the temperature of the water was reduced:—but that when he introduced the bulb into the urethra of a dead penis, while immersed in water at 118°, it rose to 114°, without sensibly reducing the tem-

perature of the water. Now it is obvious that in these experiments, Mr. Hunter overlooked the fact, that whenever any part of the living body is placed in a fluid medium above its own temperature, a large portion of caloric is transferred to the rapidly circulating blood, and conveyed throughout the body, by which the temperature of the water is reduced, and that of the body raised, as proved by the fact, that on placing the feet in hot water, the whole body becomes gradually warmed. But as there is no circulation in a dead part, the caloric of the water is not carried off by the blood, and diffused through the body; therefore accumulates in the part immersed, and without much diminishing the temperature of the water.

Were it not that the foregoing fallacies of Hunter have been embraced by many distinguished physiclogists of the present day, I should have passed them over in silence. But it is maintained by Richerand, that life has the power of generating cold, because on applying bags of hot sand along the leg of a man whose femoral artery had been tied for the cure of popliteal aneurism, he found that its temperature rose several degrees higher than that of the sound leg when treated in the same manner. But in such cases, a limb in which the circulation is nearly suspended, becomes sooner heated than a healthy one, for the same reason that the stationary surface of the

earth becomes much warmer, than the waters of lakes and seas, which are in a state of perpetual motion and circulation.

In accordance with the erroneous views of Hunter, Mason Good observes, that "in all degrees of atmospheric temperature which the body can endure, it preserves an equality of its own temperature." (Book of Nature, vol. i. p. 241.) With Sir Gilbert Blane, Dr. Paris maintains, that animal heat depends chiefly on the living principle, which has the power of regulating temperature. And Dr. Roget observes, that "man, wherever born, can go through the wide range of external temperature which lies between the freezing and boiling points, without undergoing the slightest alteration in that of his own body." (Lib. of U. Knowledge, An. Physiology, p. 109.)

The supposition that animals have the power of generating cold, was long upheld by some imperfect and fallacious experiments of Fordyce, Blagden, Dobson, and others, who reported that they had remained in air heated to from 130° to 260°, for ten and fifteen minutes, without the temperature of their bodies being raised more than 2° above the normal standard. (Phil. Trans. for 1784-5.)

But it had been previously ascertained by Dr. Crawford, that on confining a dog in air heated to 134° for fifteen minutes, his temperature under the fore arm rose from 102 to 106°; and that when placed in water at 114°, it rose from 102 to

108° in five minutes, when his respiration became hurried and distressing, his venous blood of a bright arterial hue, and his strength prostrated. (Phil. Trans. for 1781.)

In accordance with these facts, it has been recently shown by the experiments of Delaroche and Berger, that when surrounded with hot media, the temperature of man is raised several degrees above the natural standard—that when M. Berger remained sixteen minutes in a room heated to 188°, his temperature under the tongue rose 7°—while that of M. Delaroche rose 5·5° in seventeen minutes in a vapour bath at 120°. They further ascertained that when birds and the smaller mammalia were treated in the same way, their temperature rose from 10 to 14 degrees above the normal standard ; when they became greatly prostrated, and generally expired under the experiments,—doubtless, because, as I have already shown, the temperature of the solids is raised to an equilibrium with that of the arterial blood, and the process of nutrition arrested. They also found that cold blooded animals very soon died when raised to the temperature of from 104 to 108°,—corresponding with the results of Edwards, who found that frogs and other batrachians die sooner when immersed in water at 100° and upwards, than at lower temperatures.

With a view of satisfying my own mind more fully in regard to the influence of the hot and warm bath, on the temperature and circulation of

the human body, I performed the following experiments on Mr. T. B. Hopkins, a medical gentleman of sanguine temperament, aged about twenty-eight years. The temperature of Mr. H. was 100·5° under the tongue, and his pulse 72 per minute. At twenty minutes after eleven a. m. he entered a bath at 110°. In five minutes, the temperature under his tongue rose to 103°, and in five minutes more, to 106°, when his pulse was 132. At this time, the bath was at 108°, in which he remained until twelve o'clock, when it had fallen to 105°, and his own temperature to 104°, when he left it. But the most important fact connected with the experiment was, that at one o'clock, or an hour after quitting the bath, his temperature was 102° in the mouth, and his pulse 96. At two o'clock, (still in the bathing room,) his temperature was 101°, at which it remained until nine o'clock in the evening, when his pulse was 82.

If then it be true, that the temperature and circulation of a vigorous young man are kept above the natural standard for eight hours by remaining forty minutes in the hot bath, what might we not expect from its early employment in all cases of exposure to external cold, and before the cold stage of intermitting fever? Would it not prevent, or greatly mitigate, many forms of disease that prove fatal? And is it not self-evident, that after thus raising the temperature and

circulation of the body, it is capable of resisting the influence of external cold for a longer time? Hence it is that the Russians sometimes roll themselves while naked in the snow, after leaving the vapour bath,—which they could not do with pleasure and impunity, if not thus previously heated, by which the circulation through the lungs, and consequently, the process of respiration, are afterwards augmented,—especially if a bucket of cold water be thrown over the individual on coming out of the bath, so as to reduce his temperature to something like the natural standard.

At twenty-five minutes after twelve o'clock of the same day that Mr. Hopkins went into the bath, he noted down the results of the following experiments on myself. The temperature of the air was 46° out of doors, that of the mouth under the tongue was 99°, and the pulse 75, when I entered a bath at 104°. In ten minutes, the temperature in the mouth had risen to 102°, and the pulse to 88, at which they remained twenty-five minutes. The bath was then raised to 110°; five minutes after which my own temperature rose to 104°, and the pulse to 118, where they remained for ten minutes longer, when I left the bath in a very feeble condition. After walking half a mile, and dining at three o'clock on mutton chops with bread and potatoes, the temperature under the tongue was 100·5° or 1·5° higher than before going

into the bath, and at ten o'clock in the evening was 100°, while the pulse was 80. I have also found, that while moderately covered in bed, the temperature under the tongue may be raised from 2° to 3° in the course of an hour or less, by keeping a flat bottle of hot water over the stomach, and copious perspiration induced. So that when the bath is not at hand, this is a very good, although not so pleasant a method, of rousing the circulation when torpid. But it is greatly to be desired, that every house in Christendom should be supplied with the warm bath, which was justly regarded by the Greeks and Romans as a prime luxury in health, and a most important remedy in disease.

It must be observed, that when raised above the temperature of the body, water communicates a much larger amount of caloric in a given time than air, which is about 828 times lighter, and contains proportionally less free caloric in a given volume. Hence it is, that the human body is less heated when confined in air at 212° for ten minutes, than in water at 115°; and that if immersed in water at 212°, life is destroyed almost instantly. And as the attraction of water for caloric is greater than that of air, in proportion to the difference of density, the human body is more chilled in five minutes when immersed in water at 32°, than when surrounded with a dry atmosphere at 40 or 50° below 0° for as many hours. In like manner, it is probable, that if immersed in a bath

of mercury at 20° degrees below 0°, life would be extinguished in as many seconds ; for mercury is above thirteen times denser than water, and has a proportionally greater attraction for caloric.

The danger arising from exposure to a shower of rain, getting the feet wet, remaining in wet clothes, sleeping in damp sheets, or being out in cold or moist night air, are owing entirely to their abstraction of vital heat from the body. And that moist air does it far more rapidly than dry air, will appear from the following experiments, which I performed in the summer of 1840. When a thermometer was raised to 90°, and its bulb surrounded with damp cotton wool at 68°, which was the temperature of the air, it fell 22° in seven minutes. When raised to 90° and placed in dry cotton wool, it was thirty minutes in falling to 68°. It was also found by M. M. Edwards and Gentil, that by keeping one hand immersed for some time in ice cold water, the temperature of the other hand was reduced 11°. Thus it is, that by exposure of the feet, hands, and neck, to cold winds and wet, a portion of vital heat is abstracted from the blood of the whole body, during its circulation through those parts, and many fatal diseases brought on before we are aware of any danger.

It is a matter of the highest practical importance to comprehend distinctly why it is that the cold bath is invigorating, and in what states of the system it is indicated. We are told by medical

writers, that it operates by producing reaction. But they seem to have overlooked the fact, that in moderation, it augments the process of respiration, on which reaction entirely depends, as proved by the pleasurable glow of warmth that pervades the system shortly after leaving the bath. The consequence of which is, that a greater amount of caloric passes through the body in a given time, and all the functions of life are proportionally invigorated, for the same reason that they are more active during winter than summer, and more so in temperate than in hot climates. I have also shown, that besides the influence of cold in augmenting respiration, it has the immediate effect of increasing the nutritive process, especially during very warm weather, or whenever the temperature of the solids is raised nearly to an equilibrium with that of the arterial blood. Hence the importance of cold applications to the head and general system during fever, when the nutritive process is greatly diminished.

It must not, however, be forgotten, that among young children, the aged, and all persons of delicate and feeble constitutions, the mortality is much greater in temperate climates during winter than summer,—by which we are instructed to observe great caution in the employment of the cold bath in such cases. I have had repeated proofs that the temperature of strong and active young men is reduced from 3° to 4° in about ten

minutes, by bathing in the sea during summer, when the water was at 62°; and that when continued for fifteen or twenty minutes, it caused shivering, blueness of the surface, small and feeble pulse, great reduction of strength, head-ache, nausea, and even vomiting in one case.* What then must be the effect of sea bathing on delicate females with languid circulation, cold extremities, and torpor of the general system, but an aggravation of the symptoms? And what can be the general effect of the cold bath on very young children but to augment the bills of mortality?

The author was informed by a lady residing in London, who was recommended to try sea bathing as a remedy for general debility, that during the month of August, she remained in the bath at Herne Bay ten minutes, when the exhaustion was such that she had to be carried out by an attendant, and did not recover her strength during the whole of that day. I have also had occasion to observe, that the temperature of several healthy young men was reduced about 2° in the course of ten or fifteen minutes, while in the Holborn bath, which was at 82°; and that in a boy ten years old, with narrow chest and feeble constitution, a thermometer under the tongue fell from 98° to 94° in twelve minutes. We are also informed by Dr. Edwards,

* It is therefore not surprising that Leander lost his life in attempting to swim the Hellespont in December, when its temperature must have been about 50° or lower,—nor that in perform-

that when kittens a day or two old were immersed in ice cold water, (excepting the head,) they died in four minutes and a half; whereas Sir Astley Cooper found that a kitten six weeks old lived sixteen minutes when treated in the same way. It is therefore manifest, that during the early stages of infancy, the power of obtaining caloric by respiration is very limited—that it should be carefully preserved by warm clothing, and not idly wasted by cold bathing.

On the other hand, when the system has been exhausted by cold, over-exertion, or loss of sleep, there is nothing more delightful and refreshing than the warm bath, which is peculiarly adapted to individuals of the phlegmatic temperament, and to all such as are troubled with cold extremities, torpor of the circulation, indigestion, and constipation of the bowels. The best temperature in all cases is that which is most agreeable to the feelings. Finally, the warm and cold bath are only means of adding to the body, or subtracting from it vital heat. The latter is often dangerous; whereas the former is rarely if ever so.

ing the same feat on the 9th of May 1810, Lord Byron should have got the ague; for its temperature could not then have been much above 60°.

BOOK VI.

CHAPTER I.

Air and Exercise.

"If all the capacities of all ages should unite and transmit their labours, no great progress would be made in learning by anticipations; because the radical errors, and those which occur in the first process of the mind, are not cured by subsequent means and remedies. An instauration must be made from the very foundation, if we do not wish to revolve for ever in a circle, making only some slight and contemptible progress." BACON.

FROM the earliest periods of history the ancients confounded air with heat, which they regarded as the great spirit of the universe. For example, the Greek word *αηρ*, and the Latin *aura*, were evidently derived from אור *aur*,* which, in the Hebrew, Phœnician, Egyptian, and Chaldean languages, signified light, fire, and spirit. In the Treatise of Hippocrates on Air, he maintains

* The "*auræ particula Divinæ*" of Cicero, Adrian, and other Roman philosophers, was certainly not gross air, but what Pope very beautifully terms "vital spark of heavenly flame,"— which was called *aura*, because it is obtained from the air by breathing. The Latin word *spiritus* also means air or breath, and *inspiro* to breathe in air, from which the vital spirit is derived. Hence the origin of our English words spirit and inspiration.

that an exceedingly subtil and refined spirit, which he terms αηρ and πνευμα, pervades universal space, guides the sun, moon, and stars in their courses, causes winter and summer, gives life to men and all other animals. (περι Φυσων. v. vi.) He also declares expressly, in his Treatise on First Principles, that what the ancients called αιθερ, and the Greeks θερμον, or heat, is spirit; θερμον εστι το πνευμα. (περι Αρχων. i. vii.) He further maintains, that in this universal spirit resides motion κίνησις, life ψυχὴ, knowledge νόος, prudence φρόνησις, growth, dimunition, change, &c. —that a strong but invisible fire silently produces all the operations of the living body, in accordance with invariable laws.* (περι Διαιτης, B. I. sect. xi.) And it is worthy of special notice, that the Latin word *anima*, meaning life, soul, and spirit, is only a slight modification of the Greek word ανεμος, which literally signifies wind, or the air in motion. But that it did not denote the

* With Thales, Pythagoras, Heraclitus, Democritus, and Anaxagoras, he also maintained that animal heat is derived from the atmosphere by respiration; and that it is supplied to the fœtus in utero by respiration of the mother. This rational view of the subject was rejected by Aristotle, who asserts that the *office of respiration is to diminish the innate heat of the soul in the heart*. And although Galen partly adopted this absurd hypothesis, he concludes that the principal object of respiration is to preserve the *innate heat by which we live and feel;* while he represents the lungs as a vital lamp, and blood as the oil by which it is kept burning. (De Utilitate Respirationis, lib. i.)

atmosphere alone, is evident from the manner in which it is employed by Cicero, Virgil, Seneca, and many other Roman authors, who represent it as the *anima Mundi*, or soul of universal nature. Moreover, that the Greek word ψυχη did not signify air alone, but the universal spirit which "lives through all life," is equally obvious from the fact, that it is called ψυχη τȣ Κοσμȣ by many of the most profound philosophers of Greece, who maintained that the soul of man is a finite portion of the omnipresent, omniscient, omnipotent, and self active spirit, which gives motion, life, and intelligence to organized beings. (Brucker, Hist. Crit. vol. i. 467-75, 1077).

In accordance with these views of antiquity, it is remarkable, that every word in the Old or New Testament employed to represent the Supreme Creator, or any spiritual essence, was derived from the manifest agency of the sun, or of light, heat, and air. For example, we have already seen that *Al*, *El*, *Eli*, *Eloi*, *Elohim*, and *Elion*, are all modifications of the Hebrew word אל, which signifies the Creator of heaven and earth, the material sun, and the universal spiritual fluid that pervades all things. Parkhurst also observes, what no one can deny, that the Greek word Ελωϊ, as employed in Mark, c. xv. v. 34, is only a modification of the Hebrew אל, אלי, and אלוה :—that the old Greek verb εω, to be, and the word ων, being, were derived from the Hebrew

word היה, or from the noun יהוה, which has been variously written by different authors, *Iao*, *Iei*, *Yeye*, *Yehovah*, and lastly *Jehovah*, signifying the primitive essence of all existence or being.* But as the letter ο was originally employed instead of ω, which was added to the Greek alphabet at a later period, it is evident that ων is in reality the same word as *On*, which, among the Egyptians, Phœnicians, and other oriental nations, signified the sun. Hence it was, that many of the Greek philosophers employed the words το Ων and το Εν, to represent the primitive source of all existence. And it is remarkable that the words Ων and Εν are used in the first chapter of the Apocalypse, v. 8, to represent the Supreme Jehovah,—Ὁ ων, και ὁ ην, και ὁ ερχομενος,—"He who was, and who is, and who is to come."

Nor can there be a rational doubt, that the earliest impressions of mankind in regard to the existence and attributes of the Great First Cause,

* Parkhurst further states, that the Hebrew word רוח *Ruah*, signifying the spirit of God that was breathed into man when first created, also means air or breath. He moreover observes, that it has precisely the same meaning as the Greek word πνευμα, as in John c. iv. v. 24, where it is said that "God is a Spirit." But he maintains that πνευμα denotes also an incorporeal *substance,* distinct from the animal soul termed ψυχη, which man hath in common with the brutes; because he is represented as consisting of soul, body, and spirit, as in Thess. ch. v. v. 23, and Hebrews, ch. iv. v. 12. Yet he admits that both πνευμα and ψυχη mean breath, the air in motion, animal life, the human soul, and spirit. (See Greek Lexicon, under these words).

were acquired from beholding everywhere the creating and life-giving power of the sun,* or of that all pervading fire which animates the infinite multitude of suns. For it is manifest that all our ideas, whether of matter or spirit, are prototyped in the visible and tangible operations of the universe,—that they were originally derived through the senses, as demonstrated by Locke, and by the simple method of tracing all words to their primitive signification,—that there is no foundation in either nature or revelation, for the doctrine of Kant and other metaphysicians, that our ideas of the Divinity, infinite

* It is difficult to comprehend what Aristotle meant by saying, that the *Prime Mover of nature is itself immovable*, without supposing that he had a glimmering notion of the doctrine which was taught Pythagoras by Œnuphis, an Egyptian Priest of On, —that the sun is the fixed centre of light, heat, and motion, to the planetary system, as we are informed by Plutarch. (Placita Philosophorum, lib. iii. c. 2.) His account of the Trinity was also derived from Pythagoras, who received it from the east. For we are informed by the Rev. Mr. Maurice, in his Indian Antiquities, that the doctrine of a Trinity prevailed throughout the whole of Asia, north Africa, and the greater part of Europe, long before the civilization of Greece. We also learn from Sir William Jones, that among the ancient Hindoos, a trinity of powers was supposed to reside in the sun, or solar fire, whose creating, preserving, and destroying agency was represented under the names of *Brahma*, *Vishnoo*, and *Siva*,—mythological personations of the sun. In accordance with this doctrine, Aristotle observes, in the beginning of his work on Heaven, that all things are bounded by three, since the beginning, middle, and end, contain the all, and the number of the Triad—which, he adds, as a law of nature, we use in the worship of the Gods.

space and duration, are innate in the reasoning faculties, and wholly independent of the external world, or of any material organization. On the contrary, "the heavens declare the glory of God, and the firmament sheweth his handy work." (Psalm xix.)

The truth is, that elementary fire is the only appropriate representation of the Divinity; because it is everywhere present, and performs every operation in the physical universe. Could we travel with the speed of lightning for myriads of ages, we should still be encompassed by a boundless ocean of ætherial fire, which generates every ray of light, guides the planets in their revolutions, and fills them with innumerable forms of life. It is, therefore, not surprising that in so many parts of the Old and New Testament, it has been employed to represent the unknown Cause of Causes,—that it should have been declared by Moses that "God is a consuming fire," which he commanded to be kept perpetually burning on the altar of the tabernacle. (Deut. iv. 24; Levit. v. 13.) The sacred fire was also kept burning in the Jewish temple, between the cherubim, in the holy of holies, which is often described as the special seat of the Divine Presence. And it is expressly declared in the First Epistle of John, that "God is light," ch. i. v. 5, —a doctrine which seems to have been understood literally by many of the most distinguished

Fathers of the Church, who maintained that the Deity is an eternal, omnipotent, omnipresent, omniscient, and inconceivably subtil light or fiery spirit, as we are informed by Brucker, Mosheim, and others.

Should it be objected that I am treading on forbidden ground, I answer, that when God created man in his own image,* with the divine gift of reason, it was not that he should be confounded with metaphysical subtleties, which are nowhere to be found in Revelation ; and which have involved the first principles of all knowledge in profound obscurity ; while they have prevented philosophers from inquiring with unre-

* It is maintained by the author of the Whole Duty of Man, that "it was in reference to his soul, that he was made in the image of God, who is a pure spirit, and the cause of all motion and life." In accordance with this rational view of the subject, it was also maintained by Dr. Cudworth, Dr. Baxter, Samuel Clark, Dr. Dwight, and many other distinguished modern Divines, including the present Bishop of London, and Mr. Whewell, that God is the immediate cause of all the mechanical, chemical, and vital operations of nature,—a doctrine which is wholly irreconcilable with the metaphysical notion of an immaterial and superessential First Cause. In defending it, Baxter, Clark, and Dwight, reason very much in the same way as did Thales, Pythagoras, Heraclitus, Anaxagoras, and other Greek philosophers, who regarded God as the universal cause which organizes all beings out of passive matter. For example, Dr. Baxter says, that as matter is of itself passive, all those effects commonly ascribed to certain properties or natural powers inherent in matter, are immediately produced by an immaterial and self active principle. (Nature of the Human Soul.)

served freedom into the actual causes of phenomena, and led many to doubt the existence of a First Cause, or that of any spiritual essence, distinct from the properties and laws of gross matter.

The consequence has been, that we have almost as many mysteries in Natural Philosophy and Medicine, as in Religion,—that the animating principle is still confounded with occult qualities, innate properties, and undefined powers,—that the modus operandi of heat and cold, air and food, exercise and sleep, passions of the mind, medicines and other morbific agents, has never been satisfactorily explained,—that the Physician who ought to know the why and wherefore of all he does, "works his way in the dark like a mole, sells his guesses for truths, and doubts his patient to the grave,"—in short, that "no genuine physiological principle has ever yet been discovered," as truly observed by Mr. Whewell. And it is obvious, that to attempt a philosophical explanation of any of the vital functions, without a knowledge of the cause on which they all depend, is "like trying to read a cypher without previously mastering the key."

But when the science of Medicine shall have arrived at perfection, it will be found to consist chiefly in the art of employing those agents on which the operations of life constantly depend; or in making the vital principle itself by which the body is formed and renovated, the grand in-

strument of its preservation. It will then be the province of the enlightened Physician to assist nature in strict accordance with her own laws. The universal diffusion of such knowledge would enable the people to prevent nearly all the diseases by which they are now afflicted, or to cut them short before they become incurable.

There is reason to hope that a time is coming when a more simple, comprehensive, and practical knowledge of the physical, intellectual, and moral laws of the universe, will banish disease, quackery, superstition, intolerance, discord, war, and a thousand other evils from among the nations,—when the glimmering rays of light now scattered through innumerable libraries shall be condensed into a few priceless volumes,—when the science of nature shall be stripped of mystery, and reduced to the simplicity of self-evident axioms, about which there can be no essential difference of opinion,—when the many conflicting systems of religion, philosophy, and politics, that have so long distracted the world, shall be melted down into one universal code of peace and harmony. The accomplishment of this great object is surely enough to rouse the ambition, and command the support, of all those who feel within them the vocation to benefit mankind. But it must be brought about by the patient and united exertions of men honestly devoted to the study of nature and the pursuit of truth.

When it was discovered that animal life cannot be supported without the inspiration of oxygen, physiologists began to regard this gas as the primary cause of vital action. In accordance with this view, it is observed by a writer in the Monthly Chronicle, that "of the two animal wants, air and warmth, the former is incomparably the more important," and that "oxygen is the life sustaining principle of the air." (vol i. p. 221.) But I have already shown that the principal office of oxygen is to supply animals with caloric, without which it could no more maintain the action of the heart, stomach, brain, and other organs, than it could the movements of a steam engine.

And that more caloric is imparted to the blood during the respiration of oxygen, than of common air, has been proved by the experiments of many physiologists, who found that it increased the temperature of the body, the action of the heart, and with it the activity of all the functions; while it enabled the system to resist the influence of external cold and that of the mephitic gases, for a longer time than common air. From some experiments of Count Morozzo, related by Dr. Thomson, it would appear that sparrows are capable of living nearly five times longer when confined in pure oxygen, than in the same quantity of atmospheric air. For he found on placing them one after another in a vessel of air, (with potass for absorbing the carbonic acid,) that the first

remained alive three hours; the second three minutes; and the third one minute. But when he filled the same vessel with oxygen gas, he found that the first sparrow lived five hours twenty-three minutes; the second, two hours ten minutes; the third, one hour thirty minutes; the fourth, one hour ten minutes; the fifth, thirty minutes; the sixth, forty-seven minutes; the seventh, twenty-seven minutes; the eighth, thirty minutes; the ninth, twenty-two minutes; and the tenth, twenty-two minutes.

Dr. Beddoes also found that when one of two half-grown rabbits of the same brood, size, and strength, was placed for some hours in a gaseous mixture composed of one half oxygen, and the remainder of common air, it remained lively for nearly an hour, while surrounded by a freezing mixture, although its feet were frozen: whereas the one which had breathed common air, became nearly lifeless in forty minutes, and was frozen quite dead in fifty-five minutes. In another experiment, he caused one of two kittens to respire common air, and the other a mixture of two-thirds oxygen with one-third of atmospheric air for twenty minutes; when both were immersed under water until they became motionless. On taking them out, the latter recovered in one minute and a half and walked about, while the other was fifteen minutes in reviving, when it was scarcely able to stand. He further ascertained,

that when puppies were kept in hydrogen, nitrogen, and carbonic acid, until animation was suspended, they recovered much sooner in pure oxygen than in common air. (Considerations on the use of factitious airs.)

At the same time, it must be admitted, that breathing oxygen gas, tends to derange the healthy process of nutrition, by raising the temperature of the solids nearly to an equilibrium with that of the arterial blood, and thus diminishes the forces of life, as when the system is immersed in a hot bath, or exposed to the high temperature of tropical climates. It therefore follows, that the respiration of oxygen gas, like the hot bath, should be resorted to only when the temperature and vital activity of the circulation are below the natural standard, when they cannot fail to produce salutary effects.

The nitrous oxide gas, which contains a much larger proportion of oxygen than common air, and is a more rapid supporter of combustion, also produces corresponding effects on the living body. When inhaled into the lungs, it causes the sensation of a warm glow throughout the system, an acceleration of the pulse, an augmentation of muscular power, exhilaration of spirits, with sudden bursts of laughter, increased acuteness of all the senses, and a rapid succession of vivid emotions, especially in persons of the sanguine temperament. But after being breathed for some

time, it produces opposite and deleterious effects, changing the blood from its previous florid colour to a dark hue, as shewn by the purple colour of the face,—for it has been observed by Sir H. Davy and others, that after being breathed for some time, the greater part of its oxygen disappears, the residue, consisting chiefly of nitrogen and carbonic acid,—a portion of which is absorbed into the blood, causing confusion of the brain, and sometimes syncope, with more or less derangement of all the vital functions.

It has been said, that when taken into the lungs in moderation, after exhaustion from over exertion, it removes at once the sensation of weakness and fatigue, without being followed by that debility which succeeds over excitement from ordinary stimulants. There is, therefore, reason to hope that when its *modus operandi* in exalting the powers of life shall be better understood, it will be found highly important as a therapeutical agent in cases of torpor of the stomach, bowels, liver, and brain, which characterize dyspepsia, hypochondriasis, hysteria, chlorosis, and the cold stage of all fevers,—especially in conjunction with the warm bath, moderate exercise, regimen, &c.

The quantity of respiration is greatly diminished in a rarefied atmosphere, as on the tops of high mountains. The consequences of which are, hurried and difficult breathing, small and frequent

pulse, paleness or blueness of the skin, languor and prostration of strength, dimness of sight, and general loss of sensibility, nausea, giddiness, and symptoms of apoplexy, as observed by De Saussure when near the summit of Mont Blanc. The same effects are produced in a still more remarkable manner, on the high mountains of India and South America, where the amount of respiration is so far diminished, that the blood is chilled to the very centre of the system. It is well known that in the polar regions, life may be sustained for many hours with suitable clothing, when the temperature is from 30° to 50° below 0°. But Dr. Gerard states, that many lives are lost in crossing the Himalayas, when the temperature is 16° F., at the height of 14,000 feet,—owing to the united influence of rarefaction, external cold, and exhaustion from exertion. He says that in crossing the Manerung, at an elevation of 18,612 feet, respiration was hurried and difficult, long before reaching the summit—that the least motion was attended with mental dejection and debility, which compelled him to sit down every few yards.

And it has been observed on the high mountains of South America, that symptoms are produced analogous to those arising from excessive loss of blood—that when mules are attacked with hurried breathing and trembling of the limbs, they stop short, or attempt to lie down—but that if compelled to go on, they often fall prostrate,

and sometimes die in convulsions, as if suffocated by mephitic gases. That the above symptoms are greatly augmented by exertion, is evident from the fact, that aeronauts have ascended equally high with much less inconvenience, while sitting tranquilly in their cars. When on the 15th of September 1804, Gay Lussac rose in a balloon to the height of 23,040 feet above the sea, his respiration was hurried, his pulse frequent, his hands benumbed, and his body chilled throughout. And it was found by Lavoisier, that Guinea pigs could live in air that contained only one-third its usual proportion of oxygen, when the carbonic acid was absorbed by pure potass, but not without torpor and drowsiness. It is therefore probable, that men might exist at an elevation of 30,000 feet, with warm clothing, while at rest, better than at 15,000 feet in a state of exertion; for we have seen that above three times more oxygen is required during active muscular motion, than in a state of repose.

It was long ago observed by Dr. Halley, that life was supported longer in the condensed air of a diving bell, than on the surface of the earth. And the younger Brunel found that on going out of a diving bell, thirty feet under water, he could remain twice as long without inspiration, as in the ordinary state of the atmosphere. After commenting on this fact, Dr. Faraday states, that on taking a few deep inspirations, he could refrain from breathing much longer than usual.

But he adds, " those who wish to refrain from breathing should avoid action, *which exhausts the air in the lungs of its vital principle more quickly, and charges it with bad matter*." (Phil. Mag. 3rd series, vol. iii. p. 243.) It is very true that the vital principle is exhausted by exertion,—not, however, in the lungs, for *there it is obtained*, and imparted to the blood,—but in the muscles, where it is expended in *causing their action*.

Since the time of Cullen, it has been generally supposed that the mephitic gases produce disease and death, by operating as positive poisons on the nervous system, and not primarily on the blood. But carbonic acid, nitrogen, and hydrogen cannot be regarded as positive poisons, for the obvious reason, that they are at all times present in the lungs. And I shall proceed to show, that they produce their deleterious effects by diminishing respiration, and preventing the due arterialization of the blood;—that as blood is the fountain of life, and the substratum of the solids, it must be primarily affected by whatever impairs the chemical function of the lungs, in which it is generated. When animals are immersed in carbonic acid, or any of the mephitic gases, they die in about the same time as if confined in a vacuum, or as when respiration is suspended by strangulation or immersion under water. Under such circumstances, birds die sooner than mammalia, and the latter sooner than reptiles or fishes, because respiration is more

essential to the former than the latter, in proportion to the greater amount of oxygen which they require.

The symptoms that follow the inhalation of these gases in small quantities, or in a state of mechanical mixture with the atmosphere, are diminished respiration, attended with chilliness, imperfect arterialization of the blood, which is sent to the brain, stomach, and other organs, of a dark hue, as shown by the pallid or purple colour of the skin. Under such circumstances the pulse becomes low and feeble, while all the energies of life are reduced, for the same reason that they are diminished by loss of blood, breathing a rarefied atmosphere, or by depriving the system of caloric more rapidly than it is supplied by respiration. And it is worthy of special notice, that as the brain is supplied with a much larger proportion of blood than an equal weight of any other organ, it is sooner affected by loss of blood, or by whatever impairs its vital properties, than any other part of the system,—for the same reason that birds are more seriously affected by impure air than mammalia, and the latter than cold blooded animals. For example, we have seen that in birds the circulation is so rapid, that all the blood in the system passes throughout the different tissues, in something less than a minute, during which it gives out to the solids whatever amount of caloric it receives in the lungs, and thus returns to the state of venous blood, which, if not again properly

supplied with animal heat, and its arterial properties restored, there is a general reduction of temperature, and a vitiated condition of the blood, attended with universal debility.

Accordingly, the respiration of impure air is attended first with confusion of the brain, impaired vision, ringing in the ears, pain in the head, vertigo, stupor, syncope, and general loss of sensibility, or delirium. And as the contractile power of the muscles remains for some time after the voluntary influence of the brain over them is suspended, they contract spasmodically, for the same reason that convulsions are caused by loss of blood, or breathing a rarefied atmosphere. The stomach being no longer supplied with arterial blood, loses the power of digestion, and is affected with nausea or spasms, as in cholera. The pains in the head, back, and limbs, arise from a deficiency of vital heat and arterial blood in those parts, and are not essentially different from the aching sensation produced by exposure to intense cold, a shower of rain, getting the feet wet, or sitting in a cold room—all of which are owing either to an imperfect supply of the animating principle by respiration, or to its abstraction from the surface.

Among all the wonderful adaptations of nature, there is nothing more calculated to excite admiration, delight, and gratitude, than the beautiful and harmonious dependence of plants and animals on each other, for the well being of both.

In many respects, they closely resemble each other. In the first place, they are both formed of the same elementary constituents, (oxygen, hydrogen, carbon, and nitrogen,) though in different proportions. They are both furnished with organs of circulation, secretion, nutrition, and generation, all of which are maintained in a state of vital activity by the same principle. In other respects, however, they differ essentially.

For example, we have seen that plants have no breathing apparatus,* and depend wholly on the agency of external temperature for the manifestation of their powers. The consequence of which is, that they have no complex organs of assimilation and absorption, no nervous and muscular tissues, no sensation, perception, or power of loco-

* It is true that in germination, atmospheric oxygen unites with a portion of the carbon contained in the starch of seeds, by which sugar is formed for supplying the germ with nourishment, until its leaves are developed. The same process takes place during the flowering or fecundation of plants, by which a portion of the farina is converted into sugar for sustaining the embryo bud,—carbonic acid being formed, and caloric evolved, as during germination. Botanists have observed, that when the sugar of flowers has been extensively rifled by honey bees, they are rendered unfruitful. Oxygen also unites with a portion of the carbon contained in the gum and lignin of green fruits, during the process of ripening, by which sugar is formed. The leaves of plants, however, must be regarded as organs of assimilation rather than of respiration, in which crude sap is converted into cambium by the decomposition of carbonic acid, or the appropriation of its carbon, and the liberation of oxygen. Nor is it unworthy of notice, that mushrooms, mosses, algæ, lichens, and other plants

motion. But a still more remarkable difference between them is, that plants have the faculty of converting the binary constituents of inorganic matter, such as water, carbonic acid, and perhaps ammonia, into their own substance, by a peculiar species of action, intermediate between ordinary chemistry and that of animal bodies:—whereas the latter cannot be nourished except by plants that have been already organized, or by other animals that have been ultimately nourished by plants. It is therefore evident that as animals have no means of assimilating inorganic matter, they could not exist without plants.

On the other hand, it has been wisely ordained, that those substances, which are rejected by animals as excrementitious and injurious, are the appropriate food of vegetation. And it would

which have no leaves for decomposing carbonic acid, have no visible organs of circulation, secretion, or reproduction, and consist chiefly of a simple homogeneous, cellular tissue. It may also be observed here, that the lowest species of animals, which have no specific organs of respiration, have neither heart, brain, nerves, muscles, nor blood; and consist chiefly of a gelatinous mass, such as the medusa, polypus, echinus, sponge, and other zoophytes, which are scarcely to be distinguished from plants. M. Becquerel observes in a lecture delivered before the Academy of Sciences at Paris, on the 13th of July 1840, that plants have a temperature of their own, though very different from that of the surrounding media,—but that *it is inappreciable during the night, on account of their sleep, and shows itself under the influence of light.* Query: might not the difference of temperature between day and night explain the phenomenon quite as well as the supposed influence of sleep?

seem to be a law of nature, that plants not only supply animals with nourishment, but preserve the atmosphere in a state of purity, by absorbing the vast quantities of carbonic acid generated during the decomposition of organic matter, the respiration of animals, and by ordinary combustion, including what is thrown into the atmosphere by volcanoes and hot springs. For we learn from the recent valuable work of Liebig, on the application of organic chemistry to agriculture, that except during the early growth of plants, they receive very little carbon from the soil, and actually derive nearly the whole of it from the atmosphere, which contains about $\frac{1}{1000}$th part of its weight of carbonic acid, 27 per cent. of which is pure carbon. He further maintains, that as a column of air, weighing 2216.66 lbs. Hessian measure, rests upon every square Hessian foot, the whole atmosphere must contain 3000 billion pounds of carbon in the gaseous state :—that as a single man consumes 45 cubic feet of oxygen in twenty-four hours, or 16,425 cubic feet annually, 1000 millions of human beings, would increase the amount of carbonic acid in the atmosphere 100 per cent. in 1000 years, by respiration alone ; without taking into account the enormous quantities supplied by other sources.

For example, he estimates the yearly amount of oxygen consumed by ordinary combustion, in the town of Giessen, as eight times greater than

what is required for the respiration of 7000 human beings. And it is certain, that a much larger amount of carbonic acid is generated by the decomposition of vegetable and animal matter, than by all the other operations of nature. We are therefore authorized to conclude, that if the atmosphere were not continually purified by the growth of plants, it would very soon become incapable of supporting life. For it was ascertained by Dr. Dalton, that churches and other crowded assemblies, contain about one per cent. of carbonic acid, which is extremely prejudicial to health. But in the transcendently beautiful scheme of Providence, as displayed in every department of nature, partial evil only tends to the general preservation and welfare of the whole system. The demi-philosopher might pronounce carbonic acid a positive evil, because when inspired in any considerable quantities, and for a short time, it causes convulsions and death. But the Author of nature has ordained, that the formation of this same poisonous gas in the lungs, should be essential to the conversion of chyle into blood, and to the evolution of that spiritual fire by which all animals are endowed with life, sensation, the power of motion, &c.; while it is equally essential to the growth of plants, in the leaves of which it is decomposed,* the carbon

* In addition to the oxygen returned to the atmosphere by the leaves of plants, Liebig has shewn, that in the formation of

being retained, and the oxygen returned to the air in that state of purity required for the respiration of animals. In a recent Paper read before the Academy of Sciences, by M. Leblanc, he states, that in the great Lecture room of the Sorbonne, (after being filled 1h. 30m.) and in one of the Parisian churches, the amount of carbonic acid was about one per cent.; while in Hospital wards it was from three to eight times more than in the open air. But in the closed green-houses of the Jardin des Plantes, the air was pure as out of doors.

See all things with each other blending,
Each to all its being lending,
All on each in turn depending—
While everywhere diffused is harmony unending.

(Faustus, by Göethe.)

It was long ago observed by Hippocrates, that nothing is more essential to good health, than a just proportion of aliment and exercise,—that men require more food during winter than summer, because the inward heat of the body is stronger during winter,—and that as it is the tendency of exercise to diminish the substance of the body, it is the object of aliment to replace what has been lost. Yet it must be admitted,

lignin, starch, sugar, acids, and especially oils or resins, water is decomposed, its hydrogen being assimilated, and its oxygen returned to the air. (Vol. i. pp. 17—22.)

that he never fully explained any one of the vital functions.

In regard to the influence of exercise on respiration, we are indebted to the celebrated Lavoisier for the first accurate experiments, which were performed on M. Seguin, a vigorous and healthy young man. When surrounded with air at the temperature of 59° F. and at rest, it was found that he consumed at the rate of 1344 cubic inches of oxygen per hour ; but that when he performed the labour of lifting a weight of 15 lbs. to the height of 613 feet in 15 minutes, he consumed at the rate of 3200 cubic inches of oxygen per hour. It was further ascertained, that after taking a hearty meal of animal and vegetable food, he consumed from 1800 to 1900 cubic inches of oxygen per hour when at rest, during the process of digestion, and 4600 cubic inches while lifting the above weight, *ceteris paribus.* (Mem. de l'Acad. des Sciences, 1789.)

Thus it would appear, that respiration is augmented above 100 per cent. by exercise, beyond what it is in a state of repose ; and that it is increased about 40 per cent. after taking a hearty meal. The consequence of which is, that a corresponding amount of caloric is imparted to the blood, and the temperature of the whole body elevated, as shown by the increased action of the heart, the sensible glow of warmth that is experienced, and the flow of perspiration that fol-

lows.* Hence also it is, that men in health can endure a temperature of 32° during moderate exercise, with more comfort and safety, than one of 50° while in a state of rest; and that when supplied with an abundance of food, they can endure the most intense degrees of cold, so much better than during abstinence, as observed by Franklin, Ross, and other travellers in the arctic regions.

We have also seen, that the vital activity of all the organs, and the rapidity with which their composition is renewed, are in proportion to the amount of caloric that passes through them in a given time, in combination with the arterial blood by which they are nourished. But as it is a law of nature that the *cause of force is always expended in producing motion, it will be found that the vital heat of animals is wasted more rapidly during violent exercise, than it is obtained by respiration.*

* In accordance with the absurd theory of Bacon, Boyle, Borelli, Boerhaave, Haller, and many others, that heat is the effect of motion, friction, &c., it was maintained by Cullen, that "animal heat is probably the effect of the motion of the blood, because in dying animals, the heat grows less as the motion of the blood grows less; and when at death it ceases altogether, the heat ceases also in a very short time." It is almost incredible, that this sentence should have been written after Cullen was made acquainted with the great discovery of Dr. Black. Nor is it less remarkable, that Dr. C. Holland should have maintained that exercise increases respiration and animal temperature, by causing a less amount of blood than usual to pass through the lungs in a given time. (Laws of Life.)

The truth of this proposition is proved by the well known fact, that long continued muscular exertion is followed by more or less exhaustion, and by diminished power of enduring cold. For notwithstanding the elevation of temperature thus induced, the absolute amount of caloric in a state of combination with the organs, is reduced below the usual standard ; while it is equally obvious, that in proportion as respiration is increased during violent exercise, must it be diminished afterwards, for the plain reason, that a large amount of the carbon and hydrogen by which the vital combustion is supported, has been already given off in the lungs.*

As a further proof that the caloric obtained by respiration, and transferred to the different organs in combination with arterial blood, is forced out and expended during their action, it was ascertained by Dr. Granville, that during the violent contractions of the uterus which mark the progress of difficult parturition, its temperature sometimes rises to 110°, and even 120°. Dr. Edwards

* When respiration has been accelerated for several hours by exercise, it is afterwards proportionally diminished, if not supported by fresh aliment, for the same reason that a pound of fuel is sooner exhausted by a rapid combustion than when the process is moderate. This was experimentally proved by Dr. Prout, who found, that in his own person, the amount of carbonic acid exhaled was always much diminished by fatigue, abstinence from food, and the depressing emotions, or anxiety of mind. (Annals of Philosophy, vol. ii. pp. 328-43.)

also relates a case of tetanus, on the authority of Dr. Prevost, in which the temperature of the body rose 12·6° during the spasms. (Infl. of Physical Agents, p. 490.)

We further learn from some experiments of Becquerel and Breschet, that the temperature of the biceps muscle of the arm was elevated from 1·80° to 2·60°, by making it contract repeatedly for five minutes. These results were obtained by uniting two needles at their points, and thrusting them into the muscle when extended, while the other extremities of the needles were connected with the wires of a thermo-multiplier; when the rise of temperature was measured by the deflection of its magnetic needle. (Cyclop. of Anat. and Physiology, vol. ii.)

Thus we perceive, that after caloric has performed its vital office of causing a muscle to contract, it is given out in a free state, when it deflects the magnetic needle.*

I have also proved in the fourth Book and fourth Chapter of this work, that so soon as the caloric by which the particles of arterial blood

* Dr. Edwards observes, that "the first source of the heat evolved during exercise, lies in the voluntary muscles." (Cyclop. of Anat. and Physiology, vol. ii. p. 615.) But we have seen that the "first source" of animal heat is the lungs, where it is obtained from the atmosphere, imparted to the blood, and then to the different organs, where it is expended in maintaining their activity. And it might as well be said that caloric is generated *de novo* by hammering a metal, instead of being forced out from be-

are united with the different organs is expended, they successively fall from their places,* when they are taken up by the absorbents, conveyed into the general circulation, and thence through the lungs, where the greater part of their carbon and hydrogen is given off, in combination with oxygen. In the mean time, the compounds of nitrogen, oxygen, soda, lime, and other salts, together with the small remainder of carbon and hydrogen not employed in respiration, pass off chiefly through the kidneys in the form of urine, and partly through the bowels and skin. From which it follows, that every muscular contraction, every thought, feeling, or emotion of the brain, is attended with a loss of the vital heat by which all the organs are enabled to perform their respective functions, and of the substance by which they

tween its particles, as that it is generated by muscular contraction, secretion, nutrition, or any other species of vital action. Moreover, as the power of an organ when once exhausted, cannot be again restored, without an additional supply of animal heat from the blood,—so has it been found, that when the ductility of iron has been diminished or destroyed by forcing out a portion of its latent caloric by hammering, it cannot be restored until resupplied with what it had lost by exposing it to the fire.

* The extent to which the vital cohesion of the solids is diminished by violent exercise, is strikingly illustrated by the fact, that the flesh of a stag hunted to death is far more tender than if bled to death, and undergoes putrefaction in a much shorter time, as stated by John Hunter. And it was observed by Autenreith, that a muscle taken from an animal before its irritability had ceased, putrified much sooner if stimulated to frequent contractions, than if left at rest. (Müller's Elements, p. 52.)

are nourished,—that the power of vision is diminished by exposure of the eyes to a dazzling light, for the same reason that the brain is exhausted by intense thinking, and the muscles by violent exercise. Hence it is, that a daily supply of food is required to restore the waste of the solids ; and that the amount required to maintain the standard weight of the body, is always in proportion to the degree of exertion. This was strikingly illustrated in the case of Captain Barclay, who, when performing his great feat of walking 1000 miles in 1000 successive hours, consumed daily, from five to six pounds of animal food, with a proportional quantity of bread, vegetables, wine, ale, porter, and tea. (Lond. Quarterly Rev. vol. 65, p. 322.) It has also been ascertained, that without a large addition to the usual allowance of prisoners employed in the treadmills of England, they lose about one pound in weight every week, and become greatly emaciated in a few months,—that they are extremely liable to severe colds, rheumatism, bowel complaints, scurvy, and other maladies arising from debility.

It is because the substance and vital energy of the body are expended by exertion, that the growth of all young animals is retarded by premature labour. Hence also it is, that the mean duration of life among the working classes in England, does not exceed from 20 to 30 years ;

although it must be admitted that imperfect nourishment, impure air, and intemperance, augment the evil. The same observation applies to coach horses, which are worn out in a few years by active service. And it is said that in the hilly parts of Scotland, the shepherd's dog cannot labour above five or six years, but eight or nine years on the low lands.

The waste of the body is accelerated by intense cold, for the same reason that it is augmented by exercise; that is, because the animal heat by which the molecules of arterial blood are united with the solids is abstracted by the surrounding media more rapidly than it is obtained by respiration; so that notwithstanding the natives of the polar regions consume a larger amount of food than the inhabitants of warm and temperate climates, they are stinted in growth, and life is of short duration. The rapid expenditure of caloric by exercise and exposure to cold, creates the sensation of a vital want, which prompts the individual to take more deep and frequent inspirations; while the consequent waste of the solids creates the sensation of hunger, which prompts us to take more or less food, according to the amount of waste.

In like manner, the expenditure of animal heat and of the solid tissues by exercise, faster than they are renewed by respiration and nutrition, diminishes the vital energy of the brain, nerves,

and voluntary muscles, and thus creates the necessity for repose or sleep, the object of which is to repair what has been lost. Nor is it unworthy of remark, that after exposure to intense cold for a few hours, or until the body is chilled and benumbed, there is generally a feeling of drowsiness and tendency to sleep, which are also induced by exhaustion from over exertion. It is therefore evident, that *an expenditure of the vital heat and substance of the body, whether by exercise or exposure to cold, faster than they are renewed by respiration and nutrition, is the proximate cause of fatigue, hunger, and sleep.*

When the lungs are large and sound, and men are supplied with an abundance of nourishing food, they can endure protracted exercise and intense cold without serious injury.* But when exhausted by loss of blood, or when its vital properties are greatly impaired, as in phthisis, disease of the heart, the advanced stages of fever, scurvy, and some other maladies, fainting is often induced by comparatively slight exertion, and

* Edward Johnson maintains, that "it is possible by very rapid exertion, to fill almost every vein in the body with arterial blood." But as if not aware, that although arterial blood is thus rapidly formed and united with the solids, it is still more rapidly expended by exertion, he recommends walking four or five miles every morning, the same distance before dinner, and the same again in the evening. (Life, Health, and Disease, pp. 278-85.) This would, doubtless, be the way to obtain a full developement of the lungs and muscular system ; but it would certainly be at

sometimes sudden death,—obviously because the small amount of force thus expended, is not renewed by the nutritive process. It is generally known that violent exercise diminishes, and sometimes arrests the process of digestion, by diverting arterial blood from the stomach to the voluntary muscles; and that life is often destroyed suddenly by a large draught of cold water, which abstracts the small remainder of caloric from the capillaries of the stomach, and paralyzes the action of the heart. For the same reason, digestion is always impaired when the stomach is weak, and often entirely arrested for some time, by drinking cold fluids, which are a very frequent exciting cause of flatulence, colic, cardialgia, and spasms, which are more promptly relieved by hot drinks, and the application of external warmth, than by any other means.

A correct knowledge of the manner in which animal heat is expended by exercise, will enable us to explain why it is that when greatly fatigued, health is often destroyed by immersion in the cold

the expense of the brain, which is generally small among pedestrians, wrestlers, boxers, country labourers, and all individuals who take much exercise, compared with what it is in men employed in intellectual pursuits, and who lead a less active life. The true method of securing the highest degrees of physical, intellectual, and moral excellence, is to exercise all the organs within the limits of pleasurable excitement, and without producing fatigue, which is incipient disease, and should therefore be carefully avoided.

bath, which suddenly reduces the body below the natural standard, paralyzes the lungs, diminishes respiration, and thus lays the foundation of pneumonia, phthisis, or some other fatal malady, if not prevented by immediate recourse to the warm bath, or the application of dry heat, until the circulation is perfectly restored.* Nor is there a more frequent predisposing cause of fever, dysentery, cholera, diarrhæa, and congestion of the liver, than exposure to rain, fogs, damp night air, or even a moderately cool draft of air, when fatigued by over exertion, especially in hot climates, where the smaller amount of caloric obtained by respiration is much sooner expended by exercise than in the higher latitudes ; so that a very slight exposure brings on a chill, and torpor of the internal organs.

The exhaustion of animal heat by violent exer-

* I knew a case of incurable hemiplegia brought on a vigorous man in the prime of life, by walking ninety miles, (from London to Birmingham,) in three successive days. And it is well known to medical men, that when the muscles have been weakened by over exertion, they are more liable to rheumatic inflammation than at other times,—that when the loins have been overstrained, exposure to a slight cold will bring on lumbago. Nor is it possible that rheumatism or any other inflammation can exist, so long as there is a free circulation of good arterial blood through the capillaries of the muscles and other tissues. But it is consoling to know by experience, that in recent cases of rheumatism, the weakness of the capillaries may be very soon overcome by the repeated employment of hot applications, aided by gentle frictions.

cise, has been long practically recognized by sportsmen, who are careful to cover the race-horse with a warm garment immediately after he reaches the goal, with a view to prevent his taking cold. Veterinarians are also aware, that horses are far more liable to tetanus from exposure to cold, when fatigued by violent exertion, than at any other time; and that what is called a *founder*, is generally brought on by drinking too much cold water, (which is also the cause of colic,) when they have been over exercised.

Many persons imagine,—and I am not sure that even medical men are wholly free from the same error,—that the danger from exposure to cold after fatigue, is owing to what they call an *over heated* state of the body. But there is not the slightest danger of taking cold when the body is over heated by the warm bath, as proved by the Russians, who have found that it enables them to endure cold for a much longer time than they otherwise could; and that after coming out of the vapour bath, the lower orders often roll themselves in the snow with impunity. The fact is, that whenever the circulation is languid, respiration is augmented by the warm bath, which increases the action of the heart, and causes a larger amount of blood to pass through the lungs in a given time, as explained in the preceding chapters of this work.

CHAPTER II.

On Aliments.

"In cold regions, more food is necessary to enable the animal to resist the rigours of climate, and a greater degree of stimulation is requisite for the evolution of heat, than would be endured in the equatorial latitudes: while the inhabitants of warm climates are instinctively led to the choice of vegetable food; because it stimulates in a smaller degree, and is attended with a smaller evolution of animal heat." SIR CH. MORGAN.

THE object of food in the animal economy is to supply materials for supporting that incessant process of combustion in the lungs, by which the temperature and vitality of the body are maintained, and its composition renewed. Nor can there be a rational doubt, that a complete knowledge of all the changes which it undergoes while passing through the system, would explain nearly everything hitherto mysterious in the operations of life. For it involves the whole theory of respiration, sanguification, secretion, and nutrition, by which the perpetual waste of all the organs is repaired.

From the earliest periods of history down to the present time, it has been a question among philosophers, whether animal or vegetable food

is better calculated to promote health, strength, beauty, long life, and the highest developement of the intellectual and moral faculties. But we have already seen that the aliment of nations, like their clothing, habitations, manners, customs, social economy, complexion, and general organization, have been determined chiefly by climate and geographical position, to which the institutions of lawgivers and founders of religious creeds, have been, to a greater or less extent, accommodated. And it will be found, that in every part of the world, nature has supplied in greatest abundance those descriptions of food best suited to the well being of its inhabitants.

For example, the tropical regions abound with rice, yams, dates, sugar cane, and an exhaustless variety of fruits; but owing to a deficiency of the more nutritive species of grass and grain, they are less adapted to the multiplication of domestic animals than temperate climates, which abound with wheat, rye, barley, oats, potatoes, rich grasses, the olive and vine, with a great variety of fruits and vegetables: while the polar regions afford neither grass, grain, nor fruits, and no vegetable aliment excepting a few stinted mosses, but abound with reindeer, bears, seals, the walrus, and other cetacea. It is therefore evident, that nature has provided a large predominance of vegetable food in the torrid zone, of animal food in the frigid zone, and a due mixture of both in the intermediate latitudes,—con-

sequently, that if the Budhists and Brahmins of India, the Essenes of Palestine, and the Pythagoreans of southern Europe, had resided in Scythia, Siberia, or British America, they could not have required total abstinence from animal food.

It is also a beautiful provision of nature, that most of the animals in the polar regions afford a much larger proportion of oil or fat, than those of the middle latitudes; and those of hot climates still less, *ceteris paribus*. For example, it is said that the Greenland whale has been known to afford 30 tons of oil, or 50 per cent. of its whole weight, and the smaller cetacea in like proportions;* whereas the average ratio of fat in moderately well fed beef, mutton, and pork, in England, is about 25 per cent. of their neat weight.†

* By means of an immense blanket of fat, from eight to fifteen inches thick, the whale is enabled to preserve his own temperature at from 100 to 104° amidst the polar icebergs. And when employed as food, it enables the Esquimaux to maintain their temperature at the natural standard, while surrounded with air at from 50 to 70° below 0° F., with no other habitations than snow huts, and no fires except miserable oil lamps.

† According to Mr. Brande, the proportions of solid matter in the muscular and albuminous portions of fresh meat, are 29 per cent. in mutton, 27 in chicken, 26 in beef, 25 in veal, 24 in pork, 21 in cod, 21 in sole, and 18 in haddock, while it is generally estimated that the average is 25 per cent. In eggs, there is about 30 per cent. of albumen and oil, according to Dr. Christison; while in milk of the cow, goat, and ewe, the proportion of caseine, sugar, and oil, is from 12 to 14 per cent. according to O. Henry and Chevallier. So that a cow giving sixteen quarts of milk per day, would afford 3·84 lbs. of solid aliment, allowing the milk to contain 12 per cent. and 4·48 lbs. if it contained 14 per cent.—two-thirds of which would be oil and sugar.

In a full grown ox, the whole amount of lean meat is estimated at 400 lbs. But in some rare cases, the animal has been so far loaded with fat as to weigh 2000 lbs ; the proportion of fat being as four to one of muscular flesh, which contains about 75 per cent. of water, and therefore only 25 per cent. of solid matter. It must, however, be observed, that poultry, veal, lamb, venison, hares, rabbits, and nearly all wild animals, contain very little fat, more especially in hot climates.

But according to Boussingault, the proportion of solid matter in wheat when deprived of water, is 95 per cent. And if we estimate the ratio of pure flour at 90 per cent. it follows that 2·20 lbs. of wheat will afford 2 lbs. of starch and gluten ; whereas it requires 8 lbs. of lean fresh meat to afford 2 lbs. of nutritive matter when deprived of water. The potato also contains from 24 to 33 per cent. of starch and gluten, according to the analyses of M. Payen ; so that if we estimate the average at only 25 per cent. 8 lbs. must afford the same quantity as 2 lbs. of flour, and the same proportion of solid matter as 8 lbs. of fresh lean meat.

Let us now examine the chemical composition of the more important aliments. In the following table they are reduced to three classes. The first embraces the principal constituents of grain and other vegetables ; the second, the fibrin, albumen, and caseine, of both animal and vegeta-

ble food; while the third division exhibits the composition of alcohol, essence of pepper, and the most important descriptions of oil or fat.

Substances analyzed	*Carbon*	*Hydrogen*	*Oxygen*	*Nitrogen*	*By whom analyzed*
Starch	44·250	6·674	49·076	....	Berzelius
Cane sugar .	42·225	6·600	51·175	....	Berzelius
Sugar of milk	40·	6·73	53·27	....	
Grape sugar.	36·71	6·78	56·51	....	
Gum	41·906	6·788	51·306	....	Berzelius
Acetic acid..	40·	6·67	53·33	....	
Citric acid ..	41·369	3·800	54·831	....	Berzelius
Tartaric acid	35·980	3·807	60·213	....	Berzelius
Malic acid..	41·38	3·45	55·17	....	
Animal fibrin	53·671	6·878	23·688	15·763	Scherer
Do. albumen	53·850	6·983	23·494	15·673	Scherer
Do. caseine .	54·825	7·153	22·394	15·628	Scherer
Vegetable fibrin	54·617	7·491	22·083	15·809	Jones
Do. albumen	55·01	7·23	21·84	15·92	Jones
Do. caseine .	54·138	7·156	23·034	15·672	Scherer
Gelatinous tissues ...	50·048	6·477	25·125	18·350	Mulder
Calf's - foot tendon ...	49·563	7·148	24·819	18·470	Scherer
Caffeine ...	49·77	5·33	16·12	28·78	Liebig
Theine.....	50·101	5·214	15·676	29·009	Jobst
Mustard....	49·53	5·02	11·74	13·45	
Alcohol....	51·980	13·700	34·320	....	Saussure
Piperine ...	80·95	8·13	10·92	....	Göbel
Linseed oil..	76·014	11·351	12·635	....	Saussure
Olive oil....	77·213	13·360	9·427	....	Gay Lussac
Spermaceti .	78·000	11·800	10·200	....	Ure
Tallow.....	78·996	11·700	9·304	....	Ure
Lard	81·660	12·862	5·478	....	Chevreul

From the above table we perceive that the proportions of carbon and hydrogen in the vegetable acids and grape sugar, vary from 40 to 46 per cent.; in cane sugar, gum, and sugar of milk, from 46 to 48; while in the starch of grain and other vegetables, they amount to 50 per cent:—but that the fibrin, albumen, and caseine, of both animal and vegetable matter, contain about 60 per cent. and the various species of oil or fat about 90 per cent. of carbon and hydrogen, or 30 per cent. more than lean meat, and from 40 to 50 per cent. more than pure farinaceous food, sugar, gum, and the sub acid fruits.

It is therefore evident, that the latter are especially adapted to tropical and warm climates, where a smaller amount of animal heat is required than in the higher latitudes, where the articles contained in the second division of the table are more appropriate; and that in the polar regions, where animal heat is rapidly abstracted by the surrounding air during winter, oily food is peculiarly adapted for supplying its loss, by supporting a rapid combustion in the lungs. Hence it is that the Esquimaux, Samoieds, and Tungouses prefer blubber and train oil to any other description of aliment, but have no relish for vegetable food,—that they often consume 10 lbs. or more of animal and oily food per day, according to the reports of numerous travellers; who also inform us, that, while wintering in those desolate

regions, European sailors prefer the fattest meat they can obtain. And hence it is, that throughout the northern and middle latitudes of Europe, more animal food is consumed than in southern France, Italy, Spain, Portugal, and Greece,—while it is well known that in southern Asia, tropical Africa, the South Sea Islands, and nearly all tropical or warm climates, the inhabitants live chiefly on rice, bread, fruits, and vegetables, with a little milk, butter, and fat.

It also follows from the foregoing data, that a man who daily consumes 24 oz. of rice, flour, oatmeal, barley, maize, or any other species of farinaceous aliment, gum, sugar, &c. cannot afford above 10 or 12 oz. of carbon and hydrogen for the support of respiration ; whereas the same weight of fresh lean meat deprived of water would afford about 14·40 oz. ; and the various species of oil above 20 oz. But as we have seen that fresh lean meat does not contain above 25 per cent. of solid matter, 24 oz. would afford only 6 oz. of nutritive matter, and 3·60 oz. of carbon and hydrogen. In accordance with these facts, we are informed by Mr. Ross Cox, an agent of the American North Western Fur Company, that the men employed in active service, and without any other aliment, consume 8 lbs. of fresh meat per day ; and that their allowance is 10 lbs. if it contain any bone. I am also credibly informed that, under the same circumstances, the hunters

belonging to the Hudson's Bay Company consume about the same quantity of meat daily,—which would afford 2 lbs. of nutritive matter, and 1·20 lb. of carbon and hydrogen. But it is well known that a labouring man in Europe is well supported on 2 lbs. of flour, rice, oatmeal, or barley, any of which contain about 1 lb. of carbon and hydrogen, or a little more, if we allow for the gluten, which, as will be seen presently, varies from 8 to 13 per cent.* And it

* It is equally certain that men who live a sedentary life may be well nourished on a much smaller amount of the same species of aliment,—that Cornaro subsisted on 12 oz. of farinaceous food, with 14 oz. of weak wine per day, during the greater part of his long life, in the mild climate of Italy,—and that the Hindoos and Chinese live on from 16 to 24 oz. of rice per day. I know a respectable woman who, owing to a reverse of fortune, supported herself for a year, with five children, (whose ages varied from 15 to 5 years) on 26 lbs. of bread per week, 21 lbs. of potatoes, 7 lbs. of meat, 7 pints of skimmed milk, with 1 lb. of flour, a little sugar, tea, and cocoa,—the whole cost of which was 9*s.* 6½*d.* So that if we allow for 20 per cent. of water in the bread, 75 per cent. in the potatoes, 50 per cent. in the meat (including 25 per cent. of fat, which it may be supposed to contain,) and 90 per cent. of water in the milk, there remains 32 lbs. of solid matter for six individuals, or 5⅓ lbs. a week, and about 12 oz. a day for each. Yet they were all in good health, had ruddy complexions, a fine flow of spirits, never required any physic, and every meal was a luxury. A knowledge of these facts, if rightly appreciated, would be of great service to millions, who expend on spirits, malt liquors, tea, and coffee, what would afford them an ample supply of wholesome nourishment. I also know a gentleman who made the experiment of living on 24 oz. of oatmeal per day, made into porridge, with 2 pints of milk, for several weeks in succession, without any detriment to his health.

has been ascertained by Government Commissioners, that when the peasantry of Ireland have no other food than potatoes, they consume about 8 lbs. per day,—which contain the same amount of farinaceous matter as 2 lbs. of flour. It is also well known that a full sized horse or ox, weighing 700 lbs., may be well supported on 10 lbs. of grain per day; and that a lion weighing 350 lbs. requires 10 lbs. of fresh meat daily; so that if he weighed 700 lbs. he would require 20 lbs. In accordance with this fact, I have ascertained that a cat of average size requires 6 oz. of meat per day, and, if allowed, would consume much more. It is therefore evident, that the various species of grain afford a much larger amount of nourishment than the same weight of fresh lean meat.

We are informed by Major Tulloch, that the weekly rations of the British troops are 7 lbs. of fresh and salted meat, 7 lbs. of flour, $2\frac{1}{2}$ pints of peas, 10 oz. of rice, 9 oz. of sugar, 5 oz. of cocoa, and 2 pints of spirits. If, then, 7 lbs. of meat contain 25 per cent. of fat, it will make 28 oz. which contain 90 per cent. of carbon and hydrogen, or $25\frac{1}{5}$ oz. And if we suppose that 7 lbs. of lean meat contains 25 per cent. of solid matter when deprived of water, there will remain 28 oz. of muscular and albuminous matter, which contains 60 per cent. of carbon and hydrogen, or 16·8 oz., making in all 3·5 lbs. of solid fat and lean meat,

which contain 2 lbs. 10 oz. of carbon and hydrogen for the support of respiration. But if we add together the flour, peas, rice, sugar, and cocoa, they will make 11 lbs. of vegetable aliment, which contains 50 per cent. of carbon and hydrogen, or 5·5 lbs.,—making in all 14 lbs. 8 oz. of nourishment per week, independent of spirits, and 8 lbs. 2 oz. of carbon and hydrogen.

From which it follows, that a British soldier consumes daily about 2 lbs. 1 oz. of solid animal and vegetable food, which contains 1 lb. 2 oz. of carbon and hydrogen,—consequently that in the course of a year his allowance of aliment amounts to 754 lbs., of which 422 lbs. consist of carbon and hydrogen, leaving 334 lbs. of oxygen, nitrogen, sulphur, phosphorus, and salts.

In accordance with the above facts, we are informed by Liebig, that the German soldiers belonging to a company of the body guard of the Grand Duke of Hesse Darmstadt, consumed daily as much animal and vegetable food as afforded 13·9 oz. of carbon, independent of hydrogen, which must have amounted to about 2 oz., making in all 15·9 oz.* He has also proved, that so long as the body does not increase in weight, all the

* But this far exceeds the daily consumption of the civil population in any part of Europe. Liebig states, that in a family of his acquaintance, consisting of five adults and four children of different ages, the average quantity of carbon in their daily food was 9·5 oz. And I have related the case of a family,

carbon and hydrogen taken into the stomach, not discharged as urine and fæces, unite with atmospheric oxygen to form carbonic acid and water, which, like the solid excrements, are nothing else than the incombustible or imperfectly burned parts of the food; and that the compounds in which nitrogen predominates pass off through the kidneys in the form of uric acid, urea, ammonia, and the different salts:—that the superabundant carbon and hydrogen not eliminated from the lungs, are converted into fat, and deposited in the cellular tissue, where it remains until required by abstinence* or increased exercise, when it is taken up by the absorbents, conveyed into the general circulation, and thence into the lungs, from which it is given off as carbonic acid and water.

He then shews, that as caloric enough is evolved during the combustion of 1 oz. of carbon to raise 105 oz. of water 135°,—the 13·9 oz. of carbon

composed of two adults with four children, who lived on 12 oz. of animal and vegetable food, which could not have contained much above 6 oz. of carbon and hydrogen.

* In support of this view, he adduces the loss of fat and general emaciation that take place in many animals during hybernation, when they remain in a state of partial lethargy for months, without any food. He also relates the case of an individual who was unable to swallow, whose body was reduced 100 lbs. in weight during a month; and the case of a fat pig that was overwhelmed by a slip of earth, under which it remained alive 160 days, but lost 120 lbs. in weight. (Organic Chemistry, vol. ii. p. 25.)

contained in the daily food of a German soldier would, on uniting with atmospheric oxygen, afford heat enough by respiration to raise 1 oz. of water 197,477°, and 370 lbs. of water from 32° to 98·3°: —that if the quantity of heat carried off with 3 lbs. of water in the form of vapour, from the lungs and skin, be 51,1097°, there will remain 146,380° for maintaining the temperature of the body, independent of what is obtained from the combustion of hydrogen. He therefore concludes that *animal heat is derived wholly from the action of oxygen on the combustible elements of food, or of the structures formed from it*, as was long ago maintained by Black, Crawford, Lavoisier, Dalton, and many other distinguished chemists:—that it is not generated by nervous influence, motion of the blood, secretion, nutrition, muscular motion, galvanic action, &c.*

But although Liebig has more clearly ex-

* In reply to the doctrine of Dulong and Despretz, that 10 per cent. more heat is given off by animals than corresponded to the amount of oxygen consumed, Liebig observes very justly, that while surrounded by water at 47·5°, as in the experiments of Despretz, the temperature of the water was raised at the expense of the animals, which were proportionally cooled; and that if the wind-pipe had been tied, there would have been a rise of temperature in the water without any consumption of oxygen. Dumas also maintains that it is the cooling of the animal—not taken into the account by Dulong and Despretz, which expresses the excess of heat that has been attributed by them and other physiologists to a peculiar power in the system, independent of respiration.

plained the chemical source of animal heat than any of his predecessors, and triumphantly refuted many absurd hypotheses; candour obliges me to say, that he has overlooked some of the most important facts connected with the theory of respiration. For example, he maintains in various parts of his late work, that atmospheric oxygen is conveyed from the lungs to every part of the body, where it unites with carbon and hydrogen to form carbonic acid and water:—that "the globules of the blood, which can be shewn to take no share in the nutritive process, serve to transport the oxygen, which they give up in their passage through the capillary vessels." (Op. cit. p. 60.)

But that atmospheric oxygen combines with carbon and hydrogen in the lungs, is evident from the fact, that in mammalia the temperature of blood is from 1 to 3° higher in the left ventricle of the heart, pleura, and carotid arteries, than in the right ventricle of the heart, vena cava, or jugular veins, as noticed by Hippocrates, Black, Haller, Plenck, and Menzies, but fully demonstrated by the numerous and careful experiments of Dr. John Davy, which I have verified by many observations on recently killed sheep and oxen. I have also proved that, during the passage of arterial blood through the systemic capillaries, *the caloric obtained by respiration in the lungs is employed in combining a portion of its organic particles with the solids, in maintaining*

the various secretions, and the vital activity of all the functions. (See book iv. ch. ii. and ch. iv.)

I have further shewn from the experiments of Macaire, Marcet, and Michaelis, that venous contains more carbon and hydrogen than arterial blood,—consequently, that they must unite with atmospheric oxygen while passing through the lungs, where caloric is obtained, with an excess of oxygen and nitrogen. If any additional proof of this were required, it is afforded by the analyses of Mulder, (quoted by Dr. Pereira from the Pharmaceutisches Central. Blat. für. 1837, s. 325,) who found that fibrin from venous blood of the cow, contains more carbon and hydrogen than that of arterial blood, as will be seen from the following results,—to which I have added those of Michaelis, obtained by heating the dry coagulum, fibrin, and albumen of blood from the calf, with oxide of copper.

	Venous blood.	*Arterial blood.*	*Venous fibrin.*	*Arterial fibrin.*
Carbon....	52·107*	51·921	53·476	53·019
Hydrogen..	7·766	7·533	6·952	6·828
Nitrogen ..	16·700	16·800	15·295	15·462
Oxygen ..	23·405	23·744	24·281	24·691

But in the total absence of these experiments, which Liebig has overlooked, the combination of

* The average of all the results of Michaelis, as quoted by Müller, are exhibited in the above table. (Müller's Elements, p. 323.)

oxygen with carbon and hydrogen in the lungs, is sufficiently demonstrated by the facts, that the temperature of the blood is elevated while passing through the lungs, and diminished while passing through the systemic capillaries, where it ought to be raised, if oxygen there combined with carbon and hydrogen. Yet Liebig asserts, that "arterial and venous blood have the same temperature." (p. 272.) It is therefore evident, that his whole theory of respiration and animal heat is fundamentally erroneous; while in some respects it is even more defective than that of Black, Lavoisier, Crawford, and Dalton, who maintained rightly, that animal heat is evolved in the lungs, and given up by the blood to the solids in the systemic capillaries; but without explaining what office it performs in any of the vital functions. And so far is it from being true, as maintained by Liebig, that "the globules of the blood take no share in the nutritive process," that they are far more abundant in arterial than in venous blood, as proved by the numerous experiments of Prevost and Dumas, Denis, Le Canu, Mayer, Autenreith, Berthold, Letellier, and others. It is therefore manifest, that while passing through the systemic capillaries, a portion of them are dissolved, expended in nourishing the solids, and in maintaining the various secretions.

It is one of the most extraordinary facts in the history of modern science, that Liebig should

have neglected to ascertain the difference between the temperature and chemical composition of arterial and venous blood ; for this very difference constitutes the key to a right knowledge of animal physiology.* Had this celebrated chemist given us more analyses, and fewer hypotheses, he would have avoided many grave and fundamental errors, which now essentially detract from the value of his work. His explanation of the decomposition or waste of the solids, affords a curious example of the manner in which the greatest strength must fail when embarked in a wrong path at the outset.

In accordance with the foregoing hypothesis,

* The consequence of this neglect has been, that his theory of fever is more absurd, if possible, than any before offered. For example, he says, that "if in consequence of a diseased transformation of living tissues, a greater amount of force is generated than is required for the production of the normal motions, it is seen in an acceleration of all or some of the involuntary motions, as well as in a higher temperature of the diseased part. This condition is called fever." Again he observes, that "as the motions of the circulating system of the intestines increase, the power of producing mechanical effects in the limbs must diminish in the same proportion, as in wasting fevers," (pp. 229, 256.) But I have shown that the preternatural temperature of fever and inflammation is always owing to a derangement of the blood, which is no longer in a state to unite with the solids as during health ; so that the caloric which is usually transferred to the solids, is given out in the free state,—that the increased action of the heart is owing to the preternatural temperature of the blood,—and that the vital energy of the whole body is diminished, owing to a failure of the nutritive process.

that oxygen is conveyed by the blood globules to all parts of the body, he maintains that "atmospheric oxygen is the proper, active, external cause of the waste of matter in the animal body, —that it acts like a force which tends to destroy the manifestation of the vital force at every moment,"—that "*by the absorption of oxygen into the substance of living tissues, these lose their condition of life, and are separated as lifeless, unorganized compounds*,"—that "the cause of waste of matter is the chemical action of oxygen,"—that "the globules of arterial blood, in their passage through the capillaries, yield oxygen to certain constituents of the body,*—that "a small portion of this oxygen serves to produce the change of matter, determines the separation of living parts, and their conversion into lifeless compounds; while the greater part is employed in converting into oxidized products the newly formed substances which no longer form part of

* He maintains that as all the tissues of the body contain for the same amount of carbon, more oxygen than the constituents of blood—during their formation, oxygen, either from the atmosphere, or from the aliment, is added to the elements of *proteine*, which he regards as the basis of albumen, and the starting point of all the tissues,—that the gelatinous tissues contain an excess of nitrogen and hydrogen, in the proportions to form ammonia,—that vegetable albumen, fibrin, and caseine, are the only parts of plants capable of being converted into actual nourishment; and that they are identical in composition with the nitrogenized constituents of the animal tissues—not only in containing the same proportions of carbon, hydrogen, nitrogen, and oxygen, but of sulphur, phosphorus, and phosphate of lime.

living tissues,"—that "in their return towards the heart, the globules which have lost their oxygen, combine with carbonic acid, producing venous blood,—that "the globules of arterial blood contain a compound of iron saturated with oxygen, which, in the living blood, loses its oxygen during its passage through the capillaries,"—that after losing a part of their oxygen, they become venous, and combine with carbonic acid, which is given off in the lungs, when they again absorb oxygen, which is conveyed to all parts of the body,—that "*waste of matter occurs in consequence of the absorption of oxygen into the substance of living parts*,"—that in cases of starvation, and in all chronic diseases, death is produced by the chemical action of oxygen, by which every part of the body, except the bones, is consumed by a slow combustion,—and that the true cause of death in these cases, is the respiratory process. (pp. 28, 223, 238, 243, 259, 271.)

Now it is worthy of special notice, that in no part of his work, has Liebig explained what causes the constituents of arterial blood to combine with and nourish the solids: the consequence of which has been, as might naturally be supposed, that all his speculations in regard to the cause of waste have been founded on hypothetical and erroneous assumptions.* But we have

* He is equally in error with regard to the cause of the circulation; for he represents the heart as a forcing pump, which sends blood into all parts of the body; and also a suction pump, by

seen, that atmospheric oxygen unites with carbon and hydrogen in the lungs, where caloric is evolved,—that the caloric is thence conveyed into the systemic capillaries, where it causes a portion of the fibrin, albumen, and red globules of arterial blood, to combine with the solids, and to form the various secretions,—by which the temperature and vital activity of all the organs are maintained at the expense of the arterial blood, the temperature and vital properties of which are diminished, when it assumes the venous state,—that so soon as the caloric by which the particles of arterial blood are combined with the tissues is expended by their action, the vital attraction of the solids gradually ceases, when they are more or less rapidly dissolved, taken up by the absorbents, conveyed into the general mass of venous blood, and thence into the lungs, where the whole is reconverted into arterial blood, until nearly all the carbon and hydrogen are given off as carbonic acid and water ; while the remaining

means of which all fluids of whatever kind, as soon as they enter the absorbent vessels which communicate with the veins, are drawn towards the heart,—the expansion of which produces a vacuum, into which the blood is forced by the external pressure of the atmosphere. (Op. Cit. p. 58.) For the rationale of the circulation, the reader is referred to the fourth Book of this Work, Chapter III. Nor is it true, as Liebig maintains, that *the capacity of the chest, the volume of oxygen consumed, and the standard temperature of animals are the same, whether at the poles or the equator,—nor that pulmonary diseases arise from excess of oxygen, and hepatic diseases from excess of carbon* (pp. 20—24).

compounds of oxygen, nitrogen, sulphur, phosphorus, and salts, pass off through the various emunctories as dead matter.

It is therefore evident, that the "waste of matter" is not owing to "the absorption of oxygen into the substance of living parts," but to an *expenditure* of the vital heat obtained in the lungs, and transferred to the different organs while passing through the systemic capillaries,—that in cases of starvation, and in chronic diseases, death is not produced by the chemical action of oxygen, and a slow combustion in every part of the body; but that the proximate cause of death is a failure of the nutritive process, and a general dissolution of the solids, which are reduced to the state of inorganic compounds by giving off carbon and hydrogen in the lungs,—while those in which nitrogen predominates, are carried off through the kidneys and bowels as lifeless matter. Thus it is, that when deprived of food, respiration is supported, and the body nourished, at the expense of the blood,* and of its own ruins,—that the substance of the brain, nerves, muscles, &c.

* According to Dr. Le Canu, the ratio of red particles in the blood was reduced from 16·4 to 11 per cent. by eight days abstinence from nourishing food :—in another case, from 15·4 to 11·19, by the use of a liquid diet for forty days :—and in a third case, from 13·23 to 8·79, by fifteen days rigorous abstinence. It is therefore probable, that by total abstinence for ten days, the weight of the whole body would be diminished 50 per cent. The rapid emaciation that takes place during fever, is owing to a failure of the nutritive process, by which the waste of the solids is

is rapidly dissolved, conveyed into the general circulation, and thence into the lungs, where they are consumed by a slow combustion, attended with dizziness, mental debility, stupor, delirium, weakness of the limbs, hollowness of the features, and rapid emaciation, which are the leading symptoms of starvation, as described by Captain Bligh.

The observations of Liebig on the cause of animal motion, would have been noticed when treating on that subject, had not the fourth and fifth books of this work gone to the press before I examined his second volume. He there states that " everything in the animal organism to which the name of motion can be applied, proceeds from the nervous system," — that " no change of condition can occur in the body without the nerves, which are essential to all vital motions,"—that " under their influence the viscera produce those compounds, which, while they protect the organism from the action of oxygen

repaired during health, lost parts renewed, wounds healed, ulcers filled up, and the whole body restored to its former weight, after long illness of any description. Among all the wonders of nature, there is nothing more miraculous than the self-repairing powers of the living body. Nor is it very easy to explain why it should wear out in three score years and ten. Compared with this *chef d'œuvre* of the creation, the grandest inventions of human genius are but rude and imperfect imitations. Had the steam-engine the power of conveying its worn out particles to the furnace, and of converting them into new materials for repairing the loss arising from motion and friction, it would slightly approximate the perfection of the living frame.

of the atmosphere, give rise to animal heat,"—that "by means of nerves, all parts of the body, all the limbs, receive the moving force which is indispensable to their functions, to change of place, to the production of mechanical effects,"—that "where nerves are not found, motion does not exist,"—that "the excess of force generated in one place, is conducted to other parts by the nerves,—and that "from the unequal degree of conducting power in the nerves, we must deduce those conditions which are termed paralysis, syncope, and spasm." (Vol. ii. pp. 3, 30, 219, 230.)

Yet in opposition to all these assertions, (which are refuted by the well known existence of motion in plants, and in many of the lower animals that have no nerves,) he maintains in the same volume, that "*the only known ultimate cause of vital force, either in animals or plants, is a chemical process*:"—that "the ultimate cause of all the forces in the animal body is a change of material particles by the conversion of food into oxidized products,"—that "the process of chymification is independent of the vital force, and is purely a chemical action,"* (pp. 30, 32, 34, 108.)

But in direct contradiction of all these state-

* It is very true, that food may be converted into chyme by the chemical action of gastric juice alone, even out of the stomach, if kept at the temperature of the body, as demonstrated by the experiments of Dr. Beaumont and others. But does Liebig really believe, that the secretion of gastric juice is not as much a vital

ments, he observes in another place, that "*the cause of the phenomena of living bodies is not a chemical force;* it is a force which has certain properties in common with all causes of motion and of change in form and structure in material substances. It is a peculiar force, because it exhibits manifestations which are found in no other known force." (Vol. ii. p. 232.) And he tells us in the first volume, that "the vital principle is a power distinct from all the other powers in nature."

What is still more remarkable, Liebig has offered no explanation of the office or agency of heat in digestion, sanguification, secretion, nutrition, sensation, and muscular motion; but at

process as nutrition, muscular motion, or any other function? And does he mean seriously that bile is not essential to chylification, because of the small proportion of nitrogen it contains; or that it serves merely for the support of respiration? The most probable opinion is, that bile unites with chyme to form chyle, and that the excess of carbon and hydrogen not required to form blood, is given off in combination with oxygen. For it is stated by Müller on the authority of Shultz, that in oxen which had not recently taken food, there was found from 12 to 16 oz. of bile in the gall bladder, but only from 2 to 4 oz. after digestion. Hence it is, that when the process of digestion is arrested, as during fever, or only diminished, as in hot climates, there is a superabundance of bile, which is discharged by vomiting, or passes downwards, causing bilious stools. Hence also the reason why Hippocrates, Galen, and nearly all the ancients, regarded bile as the *cause* of fevers,—an opinion which has prevailed to a greater or less extent among mankind ever since, and is still most potently believed by the vulgar.

the commencement of his work, represents it as an immaterial agent, like light, electricity, and magnetism. I am therefore less surprised than I should otherwise have been, that at one time he represents all vital action as proceeding from the nervous system,—at another time, from chemical action,*—again, from a peculiar force, distinct from all the other powers of nature,—and fourthly, that he should observe in another place, "we resemble the ignorant man, to whom the motion of an iron piston rod in a cylinder, in which the eye can detect no visible agent, and

* But as he offers no explanation of the primary or ultimate cause of chemical action, it is evident that he has no fulcrum on which to place his lever, and that his whole system of hypotheses resembles that of the Hindoo, who represented the world as supported by an elephant, and the elephant by an immense turtle. For example, Liebig maintains that "all bodies in the act of combination or decomposition, have the property of inducing those processes,—that "a molecule set in motion by any power, can impart its own motion to another molecule with which it may be in contact,"—that "the most general condition for the production of *eremacausis* (a slow combustion) in organic matter, is contact with a body in that state; for the communication of combustion is in reality the effect of contact,"—of which he offers many illustrations that admit of a different and far more satisfactory explanation. (See Vol. i. pp. 221, 237, 267, 70, 74, 373.) For I have proved that caloric causes oxygen to unite with all the other elements of ponderable matter, or with any of them separately, without any previous contact with a body in the state of combustion. It is therefore perfectly natural, as caloric is evolved during every process of combustion, and as there could be no combination or decomposition without it, that the contact of a burning body should increase the chemical action of other bodies.

its connexion with the turning of thousands of wheels at a distance from the piston rod, appear incomprehensible."

Liebig further maintains, that the proximate constituents of the blood and organized tissues of animals are all originally produced in the organism of plants,—that "all such parts of vegetables as can afford nutriment to animals, contain constituents rich in nitrogen,"—that "animals require for their support and nutrition less of these parts of plants in proportion as they abound with nitrogenized constituents,"—that "no nitrogen is absorbed from the atmosphere in the vital process,"—yet that "the chief ingredients of the blood in all animals, contain nearly 17 per cent. and no part of an organ less than 17 per cent. of nitrogen,"—that "in the absence of starch, sugar, fat, gum, &c., the oxygen of the atmosphere combines with the tissues,"—that "the metamorphosis in existing tissues, and consequently their restoration or reproduction, must go on far less rapidly in graminivora than in carnivora,"—that starch, sugar, gum, fat, pectin, bassorine, wine, beer, spirits, and all substances not containing nitrogen, are incapable of being transformed into blood, and serve merely to support respiration; but that as flesh, vegetable fibrin, albumen, and caseine, contain the proximate constituents of blood and the animal tissues ready formed, they alone are capable of supporting the nutrition

and growth of animals. He therefore reduces all aliments to two classes, one of which he calls *elements of respiration, and the other, elements of nutrition,*—maintaining, that if animals were not supplied with the former, their organism would be destroyed by the action of atmospheric oxygen; and that if not supplied with nitrogenized matter, they would perish from starvation. (Vol. ii. pp. 43, 45, 75, 76, 96.)

In support of the assertion, that all the nitrogen contained in the blood and organized tissues of animals is obtained with their food, and none from the atmosphere by respiration, Liebig has offered no experiments of his own; and what is rather surprising, has not taken the slightest notice of the numerous and accurate experiments of many distinguished chemists, whose results are in direct opposition to his theory. Passing over those of Priestley, it was found by the varied and often repeated experiments of Spallanzani, on birds, mammalia, reptiles, and insects that in nearly all cases, respiration was attended with a notable disappearance of nitrogen. The same results were obtained by the still more careful experiments of Humboldt and Provençal, who found that during the respiration of fishes, the mean proportion of nitrogen that disappeared, was as 57·6 to 145·4 of oxygen. It was also ascertained by numerous experiments of Sir Humphrey Davy on himself, that about 18 per cent.

of nitrogen was permanently absorbed during respiration, —after which, similar results were obtained by Henderson and Pfaff.

These general results have been confirmed by the experiments of Macaire and Marcet, Michaelis, Magnus, Dr. Clanny, Mulder, and others, who have found that *there is more nitrogen in arterial than in venous blood,*—which could not be the case if it were not absorbed from the atmosphere. Yet we are told, that in a majority of the experiments performed by Dulong, Despretz, and Nysten, more nitrogen was exhaled during the respiration of warm blooded animals than was absorbed. What is still more incredible, (because contradicted by innumerable experiments of many of the most distinguished chemists in Europe,) it is stated by Liebig on the authority of Despretz, that more nitrogen is exhaled from the lungs of herbivora than of carnivora. But if the German Professor had examined these results with the same attention which he bestowed on Despretz's theory of animal heat, he would have found them equally fallacious.

Some highly important experiments performed by Dr. W. F. Edwards, enable us in some measure to comprehend the contradictory results of different chemists, and even those of the same individuals at different times, or under different circumstances. For example, he found that more nitrogen was exhaled by new born guinea pigs

and puppies, living on milk, (which contains much more nitrogen than vegetable food,) than was absorbed,—that the same was true of adult sparrows, during spring, summer, and autumn, until the 22nd of October; after which time, there was a striking disappearance of nitrogen; and that when yellow hammers were kept fifteen minutes in a vessel containing 94·6 cubic inches of air, during the latter part of autumn, winter, and the beginning of spring, the amount of nitrogen was diminished in almost every instance. Now although Dr. Edwards does not notice the fact, it is well known, that sparrows, yellow hammers, and most of the smaller birds, live to a considerable extent during the warmer months, on worms and insects, that afford, like milk and other animal matter, a much larger amount of nitrogen than grain, which forms the principal nourishment of birds after the middle of October, when their summer food is destroyed by the cold season. We are therefore authorised to conclude, that when animals live on vegetable food, which contains less nitrogen than is requisite to form blood, the deficiency is obtained from the atmosphere by respiration,* as shewn by the experiments of Priestley, Spallanzani, Humboldt and Provençal, Davy, Henderson, and Pfaff:—but that when

* It is during the passage of chyle, venous blood, and the waste materials of the solids through the lungs, that the whole is converted into arterial blood, by giving off carbon and hydrogen; and by absorbing nitrogen from the atmosphere, whenever that

they live on food which contains more nitrogen than is required to form blood, the excess is exhaled, as shewn by some experiments of Jurine, Berthollet, Dulong, Despretz, and Nysten. Besides, Dr. Edwards found that nitrogen was sometimes absorbed, and at other times exhaled, during the respiration of man.

But we are informed by Boussingault, that the food of a horse living on oats and hay, contained 139·4 grammes of nitrogen ; whereas his excretions during twenty-four hours, contained only 115·4 grammes of nitrogen, making an excess of 24 grammes in his food,—and that the daily food of a cow living on grass and potatoes, contained 201·5 grammes, while the excretions afforded 174·5 of nitrogen ; making an excess of 27 grammes in her food. (An. de Ch. et de Phys. lxxi. 136.)

But if we compare the relative quantities of nitrogen in the food of herbivorous and carnivorous animals, whose blood and tissues contain the same proportion of that element, it will be found that the partial results of Boussingault, like those of Dulong and Despretz, cannot be true as a general law of nature. For example, the first two columns of the following table, exhibit the proportions of solid matter and of nitrogen, in different species of vegetable food, when dried

element is deficient in the food. It is also in the lungs where blood is formed, and where, after it has performed its vital office of nourishing the tissues, the whole is converted into oxidized products, and other inorganic compounds.

at temperatures from 212° to 230°, according to the experiments of Boussingault, recorded in the Annales de Chimie et de Physique, tome lxiii. To these I have added two other columns, representing the quantities of vegetable aliment required to afford as much nitrogen as 1 lb. of lean meat deprived of water; and the proportions of nitrogenized matter in 100 parts of vegetable food. The third column was obtained by dividing the quantity of nitrogen contained in the dry fibrin, albumen, and caseine of the animal tissues, (estimated by Liebig at 17 per cent.) by the numbers in the second column. The fourth column was then obtained by finding how often the numbers in the third column go in 100 parts:—

	Solid matter.	*Nitrogen.*	*Equivalents to 1lb. of animal matter.*	*Quantity of nitrogenized matter.*
Wheat	95	2·30	7·40	13·51*
Oats	87·6	2·20	7·72	13·
Barley	86·8	2·02	8·42	11·86
Maize	82	2·00	8·5	11·76
Rice		1·39	12·23	8·17
Rye	90	1·70	10	10
Potatoes	27	1·80	9·44	10·58
Peas	83·3	4·20	4·04	24·75
Horse beans	92·1	5·50	3·09	32
White haricots	95	4·30	3·95	25
Lentils	91	4·40	3·86	25
Carrots	12·4	2·40	7·08	14·12
Turnips	8·8	2·20	7·72	13
White cabbage	7·7	3·70	4·59	22
Ordinary hay	88·8	1·50	11·33	8.82

* According to the experiments of Vauquelin, the proportion of gluten in hard Odessa wheat is 14·55 per cent. and 10·20 per

From the foregoing table, we perceive, that if only the nitrogenized portions of food were capable of being transformed into blood and the various tissues, 1 lb. of lean meat deprived of water, (which is a binary compound, and supports neither respiration nor nutrition,) ought to afford as much nourishment as 7·40 lbs. of wheat, 8·42 lbs. of barley, 10 lbs. of rye, 11·18 lbs. of maize, or 12·23 lbs. of rice,*—which is positively

cent. in that of the Paris bakers. But it would seem to vary greatly according to the nature of the soil; for Boussingault relates some experiments of Hermstedt, which show that wheat grown on a soil manured with ox blood, or human urine and excrements, afforded from 33 to 35 per cent. of rough gluten; while that produced on a soil manured by cow dung, or pigeons' dung, afforded about 12 per cent. When manured with vegetable mould, the proportion was 9·6 per cent. and 9·2 per cent. on the same soil not manured. Similar experiments should be often repeated for the purpose of arriving at greater certainty.

* It also follows, that 1 lb. of peas and beans ought to be equal in nutritive value, to 2 lbs. of wheat or barley, and 3 lbs. of rice. But even Liebig admits, that peas and beans are of inferior value as articles of nourishment, because, as he thinks, they are deficient in phosphate of lime and magnesia. It is well known, however, to farmers, that they are excellent food for horses and other domestic animals, especially when boiled or ground into meal. And I am disposed to believe that they contain a larger proportion of nutritive matter than was estimated by Sir Humphrey Davy, who represents it as 57 per cent. In wheat he found it 95 per cent. in barley 92 per cent. in rye 72·2. Again, if the quantity of nitrogen in dry hay be 1·50 per cent. and a measure of its nutritive value, $11\frac{1}{3}$ lbs. ought to afford as much nourishment as $8\frac{1}{2}$ lbs. of maize,—which is absurd, and contrary to all experience. Even Boussingault admits, that 27 lbs. of wheat are equal to one hundred weight of ordinary hay.

contradicted by all experience. For every one knows, that a horse or ox weighing 700 lbs. may be well supported on 10 lbs. of pure grain per day. But I am informed by the celebrated Van Amburgh, that a lion of the largest size requires every twenty-four hours, from 10 to 12 lbs. of clear flesh, during six days in the week; and from 16 to 18 lbs. when mixed with bone, as in a neck piece of fresh beef,—that his large tiger consumes nearly the same quantity, and the lioness about 10 lbs.—that the spotted Jaguar or Brazilian tiger, which weighs from 190 to 200 lbs. requires daily from 6 to 7 lbs. of clear flesh, and the leopard 5 lbs. If then the Brazilian tiger weigh 200 lbs. and require 7 lbs. of fresh meat per day, he would require $24\frac{1}{2}$ lbs. if as large as a full grown horse or ox. And if we estimate the proportion of water in $24\frac{1}{2}$ lbs. of lean meat at 75 per cent. there will remain 6·12 lbs. of nutritive matter, which would be consumed daily by a carnivorous animal weighing 700 lbs. But the quantity of nitrogenized matter in 10 lbs. of oats, barley, or maize, varies from 1·17 to 1·30 lb. From which it is obvious, that according to Liebig's theory, a carnivorous animal weighing 700 lbs. would take in with his food above five times more nitrogen than a horse living daily on 10 lbs. of grain. It also follows, that as there is only 1·80 per cent. of nitrogen in dried potatoes, 38 lbs. in the fresh state, would be required to

afford as much nitrogen as 4 lbs. of lean fresh meat, allowing both to contain 75 per cent. of water. And as it requires 100 lbs. of fresh turnips to afford 8·8 lbs. of dry solid matter, which contains 2·2 per cent. of nitrogen, nearly 84 lbs. would be required to afford as much nitrogenized matter as 1 lb. of dry fibrin, albumen, or caseine.*

Again, so far is it from being true, that man and other animals require less food in proportion as it abounds with nitrogen, that a much larger amount of lean fresh meat is required than of wheat, barley, or any other farinaceous aliments, as we have already seen with regard to carnivora and herbivora. We have also seen that the hunters of America consume daily about 8 lbs. of fresh meat, when they have no other food ; while it is certain that the labouring classes of Europe are equally well supported on 24 oz. of flour made into bread, with 8 oz. of fat bacon,—that the

* If then it be a fact, that lean fresh meat contains 4·25 per cent. of nitrogen, while the purely farinaceous matter of grain, potatoes, and turnips, contains only from 1·39 to 2·30 per cent. of that element, how is it possible that herbivorous animals can exhale more nitrogen than such as are carnivorous ? For we have seen that the latter consume a larger amount of food in a given time, in proportion to their weight ; and that the same amount of nitrogen enters into the composition of both classes. It therefore follows, that all granivorous animals, and a large majority of the human race, who live chiefly on vegetable aliments, must derive a portion of their nitrogen by respiration, or by swallowing it with their food in the form of air. It cannot then be admitted, that their food contains all the nitrogen found in their excretions.

Irish peasantry, who live on 8 lbs. of potatoes a day, are superior in size, strength, and activity, to those of England, where the proportion of beef and mutton consumed is three times greater than in France, four times greater than in Prussia, five times greater than in Austria, and six times greater than in Italy or Spain. The peasantry of Scotland, who live chiefly on oatmeal and potatoes, with milk,* and just meat enough to flavour their vegetable broth, are superior in health, strength, and longevity, to the north American Indians, or to any other race of men in the world, who subsist on animal food alone. It is also well known, that in almost every country in Europe, above half the population is supported chiefly on bread, milk, potatoes, and other vegetables, with a little butter and fat, which

* I am credibly informed, that the children of the wealthier classes in Scotland are fed chiefly on oatmeal porridge and milk, until the age of puberty. But the solid portions of cow's milk, when deprived of water, does not contain above 4 per cent. of nitrogen, and human milk not much over half that proportion; so that it approximates the composition of farinaceous food, the starch of the latter being replaced by oil and sugar. But according to the new theory, skimmed milk ought to afford more nourishment than new milk, because the ratio of nitrogen is larger in a given weight of the former, for the cream is supposed not to be convertible into blood. And if 1 lb. of lean meat deprived of water, contain 17 per cent. of nitrogen, it ought to afford as much nourishment as 4¼ lbs. of the solid parts of milk, which contain only 4 per cent. of that element. Such are the conclusions to which we are inevitably brought by adopting the premises of Liebig.

contain no nitrogen,—that the agricultural labourers of England, Holland, Germany, Poland, Russia, Sweden, Denmark, Canada, and New England, prefer the fattest pork they can obtain ; because they say it goes farther, and supports their strength better than lean meat. Nor is it improbable, that about four-fifths of the human race derive nearly all their nourishment from the vegetable kingdom: for it is certain, that throughout southern Asia, a large portion of Africa, the South Sea islands, and tropical America, nearly all the inhabitants live chiefly on rice, bread, yams, sugar, oil, dates, lemons, and other fruits.

But if men and other animals were nourished only by those parts of food which contain nitrogen, a man living on 24 oz. of rice per day would consume only about 2 oz. 2 drs. of aliment capable of being transformed into blood and the various tissues of the body,—all the rest being employed in supporting respiration. And if a labouring man consume 24 oz. of flour in the form of bread, with 8 oz. of fat meat, he would take only 3 oz. of actual nourishment, or about six times less than is contained in the daily food of a horse living on 10 lbs. of pure grain, which affords about 20 oz. of nitrogenized matter. But we have seen that a Brazilian tiger, weighing 200 lbs., consumes 6 lbs. of fresh beef, which contains 24 oz. of nitrogenized matter ; so that if his weight were 150 lbs. (the average of man) he

would take daily 18 oz. of matter capable of being transformed into blood, and six times more than the labouring man who lives on 24 oz. of flour, with 8 oz. of fat meat, and nearly as much as a horse weighing 700 lbs.

Is it then true, that sanguification, secretion, nutrition, and growth, are six times more rapid in carnivora than in herbivora?—that the process of waste and renovation is far less rapid in the latter than in the former, as maintained by Liebig? So far is this from being the case, that the calf, lamb, kid, and pig, grow much faster than any of the carnivorous quadrupeds.* Nor is it possible that the quantity of gluten in the food of herbivora and granivora can account for their rapid increase of weight.

The horse, ox, deer, sheep, goat, hare, and

* I have been informed by respectable butchers, that a calf 18 weeks old, fed on milk and various species of farinaceous aliment, has been known to weigh 400 lbs.; a lamb 15 weeks old, 65 lbs.; and a pig six months old, 300 lbs. It is also well known, that the hare and rabbit grow much faster than the cat, or any other carnivorous animal of the same size,—and that the deer grows more rapidly than the dog, wolf, or fox. The same general observation applies to birds. It is said by poulterers, that the domestic pigeon is nearly as large when only four weeks old as the parent bird, which consumes 1 oz. 2 drs. of barley per day. But this would afford only 1 dr. 11 grs. of nitrogenized matter, which is manifestly insufficient to renew the composition and supply the rapid waste of the pigeon. The common fowl, when well fed, is usually considered as ready for market at the age of 14 weeks; while it is certain that the turkey, ostrich, and other granivorous or frugivorous birds, grow faster than the eagle, vulture, and other birds of prey.

rabbit have a higher mean temperature, with proportionally greater power of enduring cold and prolonged muscular exertion, than the lion, tiger, leopard, hyena, cat, or any species of carnivorous mammalia, if we except the dog, wolf, and fox, whose blood is not richer in organic particles than that of the more active herbivora. And it has been observed, that the greyhound, when fed on hard biscuit, with milk and fat, is not less swift as a runner than when supplied with lean meat. There is also reason to believe, that during recovery from long illness, the weight of a man, nourished chiefly on farinaceous and saccharine food, increases at the rate of about 8 oz. per day. And as we have seen that men require two or three times more lean meat for their support, than of purely farinaceous and oily aliments, we are authorized to conclude, that starch, fat, gum, and sugar, not only support respiration, but that during this process, they are transformed into blood (by absorbing nitrogen from the air,) capable of nourishing the tissues, like gluten and the nitrogenized portions of animal food.*

* Dr. Paris thinks that an ounce of fat contains nutriment equal to 4 oz. of lean meat. (On Diet, p. 72.) Nor can there be a rational doubt that honey, sugar, sago, tapioca, and arrow root, which contain little or no nitrogen, are highly nutritious. I have also been frequently told, that the blacks of the West Indies and Brazil are never so hearty and well looking as when they live freely on juice of the sugar cane, with molasses. And we are informed by Dr. Pereira, of an English woman who was nourished

The opinion that substances not containing nitrogen are incapable of supporting animal life, has been erroneously inferred from some experiments of Magendie, who found that when dogs were fed on sugar, butter, olive oil, or gum, separately, with only water, they died in from thirty-one to thirty-four days. But he also found afterwards, that when rabbits and guinea pigs were fed on wheat, barley, oats, carrots, or cabbage, separately, with water alone, they died with all the symptoms of starvation in fifteen days, but suffered no ill effects when fed on the same articles simultaneously, or in succession. (Physiology Trans. by Milligan, vol. ii. p. 486, 2nd ed.) It has also been clearly established by a Report of the Gelatine Committee, (in the Comptes Rendus des Séances de l'Académie des Sciences, vol. v. Août. 1841,) that *fibrin*, *albumen*, and *gelatine*, when taken alone and separately, will not support the life of dogs, although carnivorous

several years on refined sugar alone. It is therefore impossible to admit the assertion of Liebig, that starch, sugar, gum, and oil are incapable of being transformed into blood by the chemistry of animal life. For it is manifestly not true, as he maintains, that the quantity of nitrogenized matter in the food of herbivora is amply sufficient for the growth and developement of their tissues, and for the supply of waste. If this were the case, a cow fed on 42 lbs. of turnips would consume only 2 oz. of nitrogenized matter; whereas the milk of a cow giving 16 quarts would contain above 20 oz. of caseine, which contains about 16 per cent. of nitrogen, or 3·20 oz.

animals :—but that an exclusive diet of muscular flesh, raw bones, or gluten, is capable of complete and prolonged nutrition. (Pereira's Lect. on Foods, Pharm. Journal, Oct. 1842.) Hence the vast importance to health of a mixed and varied diet, as indicated by the appetite, and the diversity of aliments supplied by nature.

There is reason to believe that the best possible nourishment for man is a mixture of animal and vegetable food in such proportions as to produce a composition resembling milk, which Dr. Prout very justly regards as the model of what our aliments should be in after life. He observes, that nearly all our artificial combinations of food are nothing more nor less than disguised imitations of the prototype milk; and that the more nearly they approach this model, the more nearly do they approach perfection. For example, by adding to flour fat, sugar, and eggs, as in making pastry, we have a composition very nearly analogous to that of milk, which was evidently intended by nature for the nourishment of animals during a considerable period of their existence. Now it will be seen from the following analyses of O. Henry and Chevallier, that the average proportion of caseine in milk of the cow, ass, goat, and ewe, is as 1, to 2·23 parts of oil and sugar; while in that of woman, the difference is as 1 to 5·76.

	Cow.		*Ass.*		*Goat.*		*Ewe.*		*Woman.*
Caseine..	4·48	..	1·82	..	4·02	..	4·50	..	1·52
Butter...	3·13	..	0·11	..	3·32	..	4·20	..	3·55
Sugar...	4·77	..	6·08	..	5·28	..	5·00	..	6·50
Salts....	·60	..	·34	..	·58	..	·68	..	·45
Total....	12·98		8·35		13·20		14·38		12·02

Liebig maintains that the proportion of caseine in the milk of woman is increased by her living on animal food; while the proportion of oil is increased by a farinaceous diet. (Vol. ii. p. 83.) But we perceive from the above Table, that the ratio of caseine is 2·6 times greater in the milk of herbivorous animals than in that of woman, who lives partly on animal food. It also follows, according to Liebig's theory, that nearly six times more aliment is required to support the respiration of an infant, than is employed in its nutrition, and 2·23 times more in the calf, colt, kid, and lamb. But so far is this from being the case, that the temperature of the calf, kid, and lamb, is several degrees higher than that of the infant; while experience demonstrates that human milk is not less nutritious than that of other animals. The inference is therefore clear, that the sugar and butter of milk, like the starch of grain and other vegetables, serve not merely to support respiration, but is also convertible into blood and the various tissues,—consequently, that there is no foundation in nature for the

division of food into "*elements of respiration and elements of nutrition.*"

The obvious tendency of Liebig's theory is to augment the consumption of animal food among mankind. But it is worthy of special notice, that *no highly civilized nation has ever yet been strictly carnivorous,*—that the teeth, jaws, stomach, bowels, and whole organization of man, resemble those of the monkey tribe much more nearly than those of carnivora,—consequently, that man is specially adapted by nature to a vegetable diet, which, if sufficiently varied, is equally palatable, and far more conducive to health, strength, beauty, sweetness of body, intelligence, morality, and urbanity of manners, than a diet of animal food alone,—if not preferable to a mixture of both.

In support of this view, it may be observed, that in all the attributes of a beautiful and vigorous organization, mildness of disposition, docility, and usefulness, herbivorous animals are far superior to the carnivora, nearly all of which are characterized by ferocity, a fetid odour of the skin and breath, with a rank, disagreeable taste of the flesh, which was doubtless the reason they were forbidden as food by the laws of Moses. I therefore agree with Pythagoras, Dr. Lambe, and Mr. Shelley, that much of the savage cruelty which has characterized many barbarous tribes of mankind, may be ascribed to their exclusive use of animal food; although it must be admitted

that some of the tribes inhabiting central Africa and the South Sea Islands, who live on fruits and vegetables, have been equally ferocious and cruel.

The superiority of vegetable over animal food is still more striking in an economical point of view. For example, if we estimate the average produce of wheat at 1250 lbs. per acre; a square mile, or 640 acres, would yield 800,000 lbs., which would support a population of 1462 individuals, allowing each to consume 24 oz. per day throughout the year. And it is well known that an acre of ground will produce from 40 to 50 per cent. more barley, maize, oats, beans, or peas, than of wheat. But if the products of an acre of ground be required to give 200 lbs. of meat on an average, a square mile would give 128,000 lbs.: so that if it contain 25 per cent. of fat and 25 per cent. of lean meat, deprived of water, there would remain 64,000 lbs. of nutritive matter, which would support 117 inhabitants, allowing 24 oz. for each. From which it follows, that land sown in wheat would support above $12\frac{1}{2}$ times the number of inhabitants that it could if devoted to the rearing of cattle and sheep.

But at present the number of horses in Great Britain is 2,166,000, and of cattle 13,000,000: so that if each of these animals consume as much food as five men, that of the whole would maintain a population of 75,830,000. If to this we

add 56,000,000 sheep and 25,000,000 pigs, their food would support a population of 50,000,000 human beings, independent of what is employed in feeding poultry, deer, dogs, and cats. And if an acre of ground can produce 22,000 lbs. of potatoes, which are equal to 5500 lbs. of wheat, a square mile would support 4821 human beings. Nor is it improbable that the time may come, when animal food and woollen clothing will be exchanged for a vegetable diet (with perhaps milk, butter, eggs, and fish,) and cotton clothing, —when the work of animals will be performed chiefly by steam power,—when the population of England shall be augmented from 280 to 1000 on the square mile,—and by a judicious variation of their vegetable diet, live far better than at present.* The following Table, compiled by a recent author of great merit, who has chosen to remain anonymous, exhibits an estimate of the relative quantities of food that an acre of ground will produce in temperate climates :—

* In the north eastern provinces of China, where very few animals are reared for food, and still fewer for labour, the population varies from 500 to nearly 800 on the square mile, without the advantage of machinery and other means of augmenting the comforts of life. It is therefore evident, that with the vast resources of Britain, and the adoption of a diet consisting chiefly of vegetables, she is capable of supporting in comfort more than 100,000,000 inhabitants, and that in such a state of things, there would be no necessity for migration to other countries.

Potatoes	22,000 lbs.	Plums and Cherries ..	2000
Mangold Wurtzel	22,000	Oats and Barley	1840
Parsnips	11,000	Wheat	1250
Cabbages	10,000	Mutton	224
Turnips	8240	Beef	186
Apples	7000	Milk	2900
Pears	5000	Butter	300
Onions	2800	Cheese	200
Beans and Peas .	2000		

With regard to the quantity of aliment required to maintain health and strength, much depends on climate, season, age, sex, temperament, and mode of life. To persons in robust health, scarcely anything in the rich banquet of nature comes amiss; whereas, the feeble and phlegmatic require moderation, and the choice of a light but nutritious diet. Perhaps there is no better guide than the instinctive appetite implanted by nature, which if not perverted by artificial and vicious customs, always prefers what is salutary, but revolts from the use of drugs and poisons. Let every one then partake in moderation of what he likes best, and cure repletion by abstinence, or exercise, rather than resort to emetics and purgatives.

When more food is taken than is required to repair the waste of the solids, there is a superabundance of imperfectly formed blood, that abounds with oily matter, which if not carried off by suitable exercise, deranges the nutritive process, causing a feverish state of the body, indi-

gestion, head ache, low spirits, hysterics, gout, &c. For example, it is well known to the feeders of poultry, that after being crammed for ten days or two weeks, until loaded with fat, they become feverish and drooping. It is therefore obvious, that a large accumulation of fat is incompatible with a healthy condition of the blood, and should be prevented either by abstinence or by exercise, which, according to Lucian, performs the same office which winnowing does for corn, by blowing away the chaff and other impurities, while the pure grain is left behind.

Nearly all descriptions of food are more digestible and nutritious when cooked, than in the raw state, if we except the softer species of ripe fruits, (which are already more or less cooked by the heat of the sun) and oysters, the albumen of which is coagulated like the white of eggs, by a high temperature. For the same reason, warm meals are more easily digested by weak stomachs, than when cold. And we are told by the Chevalier Edelcrantz of Sweden, that the process is accelerated by warm clothing, but retarded by whatever reduces the temperature of the body below the natural standard.

In regard to the modus operandi of ardent spirits, wine, malt liquors, and other stimulants, on the animal economy, very little has been ascertained with certainty. It is generally understood, that their activity is in proportion to the

amount of alcohol they contain, which varies from 50 to 54 per cent. in spirits; from 10 to 26 in wines, and from 4 to 8 per cent. in porter and ale. But that caloric is the active principle in alcohol, would appear from the fact, that when swallowed pure, or even diluted with nearly one half water, as in brandy, gin, and whiskey, it produces a burning sensation in the throat and stomach, like so much liquid fire. And it is generally known, that the sudden mixture of alcohol with water, is attended with a considerable elevation of temperature. The same heating influence is produced in the body by æther, ammonia, and other stimulants.

Liebig maintains that the carbon and hydrogen of spirits, wine, and malt liquors, unite with atmospheric oxygen within the body, and assist in the generation of animal heat, because, as he says, the expired air, perspiration, and urine, do not contain any trace of alcohol after it has been used. This is doubtless the case when they are taken in small quantities, especially in combination with food. But when taken alone, or in large quantities, they may be always perceived in the breath. They have also been detected in the blood, the ventricles of the brain, and in the excretions, according to Magendie.

When taken in moderation, there is reason to believe that drinks containing alcohol, augment the process of respiration, by increasing the action

of the heart, and the circulation of blood through the lungs,—thus producing a pleasurable glow of warmth throughout the body, a temporary flow of animal spirits, and an accelerated activity of all the functions. In accordance with this view, we are informed by Dr. Paris, that Mr. Spalding consumed the oxygen of the air in his diving bell, much sooner, when he drank spirituous liquors, and employed a diet of animal food, than when he drank only water, and lived on vegetables. On the other hand, it was found by the experiments of Dr. Fyfe, and Dr. Prout, that the amount of carbonic acid generated in a given time by respiration, was always materially diminished by the use of spirits, wine, and malt liquors, especially, when taken on an empty stomach. (An. of Philos. Vol. ii. p. 328—Vol. iv. p. 334.)

Nor can there be a doubt, that when taken in large quantities, they are absorbed into the blood, and conveyed to the brain, where by their narcotic influence, they diminish its voluntary command over the function of respiration, as shown by the coldness of the extremities, languor of the circulation, giddiness, stupor, insensibility, loss of appetite, nausea, tremors, and general prostration of strength, that characterize intoxication, which literally means the action of a poison. It is therefore not surprising that their habitual use induces delirium, paralysis, apoplexy, epilepsy, madness, and a frightful train of physical mala-

dies, especially in hot climates. For it is certain, that they may be consumed in much larger quantities in cold than in warm and tropical countries, without causing intoxication or disease. And this proves that they afford a certain amount of caloric either by uniting with the fluids of the body, or by increasing respiration, in the same way that animal food and fat produce this effect. Hence it is, that when the energies of life are exhausted, as in the latter stages of typhus, cholera, tetanus, and other low forms of disease, they are often revived by the judicious employment of brandy, æther, wine, &c.

Yet there cannot be a rational doubt, that the abuse of these articles has caused a greater amount of physical and moral suffering, than war, famine, pestilence, or any other single calamity. If, by virtue of a strong constitution, a few drunkards have arrived at old age, millions are destroyed in the prime of life by intemperance. That intoxicating liquors are not sanctioned by nature, would appear from the fact that they are generally disagreeable to the unvitiated taste of the lower animals and of young children; while it is notorious that their constant use diminishes the appetite of adults for wholesome food. The sooner we begin to assist nature by stimulants, the sooner she leaves us a prey to artificial excitement, which is seldom beneficial, except when the powers of life are reduced

below par. If the 50 millions sterling, annually expended for spirits, wine, and malt liquors, in Great Britain, were rightly employed in the promotion of a sound physical and moral education of the lower classes, pauperism would soon disappear; while vast multitudes would be rescued from crime, madness, and premature death.

Recapitulation.

The cardinal facts embraced in this Chapter may be reduced to the following general propositions:—

1. That each zone affords in the greatest abundance those descriptions of aliment best suited to maintain the well being of its inhabitants.

2. That excessively cold climates abound with animals which contain a large amount of oil and fat, that are rich in carbon and hydrogen, which afford an abundant supply of animal heat where it is most required.

3. That the middle latitudes abound with grass, grain, and domestic animals, which are less numerous, and contain a much smaller proportion of fat in hot climates, where there is an exhaustless profusion of saccharine fruits, gum, and farinaceous aliments, that afford less carbon and hydrogen, therefore, less caloric by respiration, than animal food.

4. That the various species of grain afford a much larger amount of actual nourishment, than

an equal weight of animal food, if we except cheese, butter, fat, and lean meat deprived of water.

5. That during the process of respiration, starch, sugar, gum, and fat are converted into blood, by absorbing nitrogen from the air, and by giving off carbon and hydrogen; consequently, that the elements of respiration, when combined in due proportion, are employed in nourishing the solids, like the fibrin, albumen, and caseine, of both animal and vegetable food.

6. That as the chemical composition of all animals is the same, herbivora must derive a portion of their nitrogen from the atmosphere, because their food does not contain enough of that element to maintain their nutrition and growth, which are even more rapid than in carnivora.

7. That the living body is a self-repairing machine, which has the power of transforming both ternary and quaternary compounds into its own tissues; and when wholly deprived of food, is capable of living for many days on its own ruins, which are repeatedly renovated in the lungs, where they are also gradually converted into carbonic acid, water, and other inorganic compounds.

8. That the rapid increase in the weight of the body after long abstinence or illness, the speedy healing of broken bones, the filling up of ulcers, and the rapid growth of herbivorous animals, all

tend to prove, that the nitrogenized portions alone of vegetable food are insufficient to account for the renovation of their composition, and the supply of waste.

9. That a suitable variety of vegetable aliments is better adapted to the organization, health, strength, intelligence, and moral excellence of the human race, than a diet of animal food alone.

10. That although spirits, wine, and malt liquors,* when taken in moderation, elevate the temperature of the body, augment the circulation, produce a temporary flow of spirits, remove the sensation of hunger, fatigue, and other disagreeable feelings,—they impair the vital properties of the blood, and diminish its coagulating power, when used to excess,—derange the nutritive process, cause a dropsical or phlegmatic condition of the solids, and gradually destroy the *vis medicatrix naturæ,* as shown by the slowness with which wounds and ulcers heal in intemperate drinkers.

* It is important that every one should know there is about three times more solid and nutritive matter in a pint of milk than in the same measure of porter, and 20 times more in a pound of good bread. Yet 35 million bushels of barley are wasted annually in England in making malt liquors, (which vitiate the breath and gradually destroy health,) or enough to nourish 3½ millions of human beings. Nor is there a more palpable error than the general opinion that malt liquors are essential to support the strength of a labouring man. But it is in vain to reason with men whose appetites and reasoning faculties have been perverted by artificial customs.

CHAPTER III.

Sleep,

> " that knits up the ravelled sleeve of care,
> The *birth* of each day's life, sore labour's bath,
> Balm of hurt minds, great nature's second course,
> Chief nourisher in life's feast."

THE essence of nearly all that has been written on the subject of sleep, from the time of Hippocrates to the present day, is contained in the above lines of Shakespeare. But the rationale of the process has never yet been explained in a philosophical manner. I have already shown that the power of the stomach to digest, of the muscles to contract, of the brain to think, and of the nerves to feel, is directly in proportion to the rapidity with which their composition is renewed, *ceteris paribus*,—but that the animal heat obtained by respiration, and the organic particles of arterial blood by which the solids are nourished, are still more rapidly expended by the action of the brain and voluntary muscles, than they are renewed—in short, that the cause of force is always expended in pro-

ducing motion or action,—that the object of aliment is to supply materials for supporting respiration, and for repairing the waste of the solids, induced by exercise,—after which it is carried out of the system by the different emunctories, in the form of carbonic acid, sweat, urine, &c.

I shall now proceed to shew, that *the proximate cause of sleep is an expenditure of the substance and vital energy of the brain, nerves, and voluntary muscles, beyond what they receive when awake;—and that the specific office of sleep, is the restoration of what has been wasted by exercise.*

That the necessity for sleep arises from an exhaustion of sensorial and muscular power, would appear from the fact, that it is induced by intense bodily pain, laborious exercise of the brain and voluntary muscles; when not carried so far as to interrupt the nutritive process. So pressing is the demand for it in cases of painful and difficult parturition, that women often fall into a slumber between the paroxysms of violent uterine contraction. They also require more sleep during gestation, than at other times, owing to the expenditure of blood and vitality in support of the fœtus. In accordance with these facts, sleep is more profound and long continued, after the body has been greatly wasted by protracted illness, or exhausted by over exertion of any description, whether of the nervous or muscular organs.

Again:—that the system actually increases in

its dimensions during sleep, but diminishes while awake, and in a state of action, would appear from the fact, (which I have verified by numerous measurements,) that an ordinary sized man is from 8 lines to one inch taller in the morning, after a good night's repose, than in the evening. Some Physiologists have maintained that this is owing to an expansion of the intervertebral cartilages, after the superincumbent weight of the body is removed, and to their compression when in the erect posture. But that it is owing to increased growth of the whole body, is proved by the smoothness and plumpness of the features and limbs, the rapid healing of wounds, and the speedy recovery from the wasting effects of long illness, during and after sound repose,—by which the animal frame is filled with new life, exhaustion removed, the vivacity of the mind and the vigour of the muscles restored.

Thus it is evident, that sleep is the "chief nourisher in life's feast;" and "a remedy for every curable disease," as long ago observed by Menander. Nor is it less certain, that the whole body is wasted, and the features contracted, after long watching, by which the *vis medicatrix naturæ* is diminished,—and that nothing tends more effectually to injure the constitution than loss of sleep, by which it is rendered extremely liable to the noxious influence of cold, malaria, and other causes of disease. It is also worthy of notice, that

young animals sleep more during the period of rapid growth, than after they arrive at maturity. Hence the remarkable activity and sprightliness of children, after the term of infancy is passed, and they have acquired the free use of their locomotive organs. In like manner, many persons who have attained their full growth, enjoy better health and spirits after great emaciation from severe illness, and excessive medication, than for several years before, provided no serious disorganization has taken place. The reason of which is, that after the body has been much reduced, and the disease arrested, the process of renovation by nutrition is more rapid than during an ordinary state of health ; so that in respect to growth, intellectual vivacity, and general excitability, the individual returns for a time to the charming condition of a new and youthful existence.

It is maintained by Edward Johnson and other Physiologists, that nutrition goes on only during sleep. But I have proved that during the contraction of every muscle, and during every action of every organ, there is an expenditure of substance and vital energy, in proportion to the activity of each,—and that, if not perpetually renovated by a fresh supply of arterial blood and vital heat, animal motion, and all the operations of the nervous system, are extinguished in a few minutes. So far is it from being true, that the formative process goes on only during repose, or

quiescence of the brain, nerves, and voluntary muscles, that respiration and sanguification, secretion and nutrition, are greatly augmented during violent exercise:—for it is well known that the more vigorously any organ is exercised, the more abundantly is it supplied with arterial blood. Hence it is, that more food is required by men who take much exercise, than by such as lead a sedentary life. Yet as the animal heat by which the organic particles of blood are united with the solids, is more rapidly expended by exertion through the day, than it is obtained by respiration, the vital affinity by which the said particles are held in combination with the solids is very soon dissolved, when they are removed by the absorbents, and replaced by new ones, as shown in the foregoing parts of this work.

It is only, however, the brain, nerves, and voluntary organs, whose substance and power are so greatly exhausted by exercise; for as the action of the lungs, heart, stomach, bowels, and other involuntary organs, is more nearly the same at all times, the process of renovation is generally equal to that of waste, and they never require absolute repose, but continue in action throughout the whole period of existence.

The most remarkable difference between exercise and sleep is, that during the former, the expenditure exceeds the income; whereas, during the latter, the income exceeds the expenditure. For example, if the annual income of an individual be 500 pounds,

and his expenses 1000 pounds, it is obvious, that unless the latter be materially diminished for a time, his whole capital must be very soon exhausted. In like manner, if the substance and vital heat of the body be expended by exercise of the brain, nerves, and voluntary muscles, with twice the rapidity that they are replaced by respiration and nutrition, it becomes evidently necessary that the activity of the system should be suspended, until the loss is repaired, which is most effectually accomplished during repose, when the expenditure is at the minimum. Thus it is, that although respiration is diminished 20 per cent. about the middle of night, even when awake, if the body be at rest, according to the experiments of Dr. Prout, and probably still more during sleep; yet the income greatly exceeds the waste.

That a larger amount of animal heat is retained in the body during sleep, when sufficiently covered, than during the exercise of the day, would appear from the fact, that the temperature under the tongue is one or two degrees higher on first awaking in the morning, than at bed time; except after exercise, or taking a hearty supper, both of which augment respiration. This explains why it is that in hot countries, where the inhabitants take an afternoon nap, the face, neck, and whole surface of the boy, perspire more than if awake at the same time, *ceteris paribus*. And Sanctorius informs us, that during

seven hours sleep, the fluid exhaled from the skin of a healthy man was about double what was lost in the same time while he was awake. (Med. Stat. Sect. 4.)

But as less caloric is obtained by respiration during sleep than when we are awake; if the body be not well covered, it is more easily chilled, and the circulation depressed, than during exercise. Hence it is, that when exhausted by previous exertion, the caloric obtained by breathing is still more rapidly abstracted by exposure to cold and damp night air during sleep, than it is replaced,—by which the body is predisposed to a chill, which ushers in all the different forms of fever and other constitutional maladies. M. Quetelet states in his recent statistical work on man, that the number of inspirations are diminished during sleep, in the ratio of 6 to 7 when awake; and the pulsations at the wrist, in the ratio of 3 to 4 per minute:—that among 300 individuals, at different ages, the extreme values were as represented in the following table:—(see p. 71.)

	Inspirations.	*Pulsations.*
At birth	44	136
Five years	26	88
15 to 20	20	69·5
20 to 25	18·7	69·7
25 to 30	16	71
30 to 50	18·1	70

But that the diminished frequency of the heart's action during sleep is owing to the cessation of

voluntary motion, has been demonstrated by Dr. Knox, who found that in a healthy young man of regular habits, aged 20, the average number of pulsations at 7 in the morning, was 7·4 beats greater than at 10 in the evening, independent of food and exercise.

	horizontal.	*sitting.*	*standing.*
Average morning pulse	62	78·3	90
Average evening pulse	56	67	77

He has further shown, that the excitability of the heart diminishes regularly from an early hour in the morning until midnight, when it is at zero. And I have found that the mean temperature under the tongue, *ceteris paribus*, is from 1 to 2 or 3° higher early in the morning than at midnight.

As might naturally be supposed, Dr. Knox observed, that the action of the heart was greatly reduced by sitting in a cold room :*—that its pulsations are most frequent in infancy, and diminish on till old age, when they are at a minimum :—that they are more accelerated by food and exercise in the morning and during the forenoon, than in the afternoon, and least of all in the evening,—more in weak than in strong individuals; but that this does not apply to wine and spirituous liquors :—finally, that the action of the heart is augmented more by muscular exertion, than by fever or any other cause. (Ed.

* Blumenbach says the pulse is slower in cold than in tropical climates, where the mean temperature under the tongue is about 2° higher than in England, as shewn by Dr. J. Davy.

Med. and Surg. Journal for 1813-14-15.) Nor is this latter fact at all surprising, when we reflect that from three to four times more caloric is disengaged by respiration during active exercise, than when we are at rest. Nor is it difficult to comprehend, why the action of the heart is more strong and frequent in the morning than evening, when we reflect that more animal heat is expended by exercise during the day, than is obtained from the atmosphere by respiration.

It is said by M'Nish, that birds sleep less than mammalia, and the latter less than man, who requires more during winter than summer, and more in cold than in hot climates. However this may be, it is certain, that during the long nights of winter, for some time before and after Christmas, the cock frequently crows at intervals, as if not disposed to sleep so long. During the prime of life, men require from six to eight hours sleep, if we except those of large chests, vigorous constitutions, and sanguine temperament, who are able to endure great muscular and intellectual exertion with much less repose, than individuals of the phlegmatic temperament. During the most active period of their lives, Alexander, Julius Cæsar, Napoleon, Washington, the Duke of Wellington, Lord Brougham, and many other distinguished men, have not slept above four or five hours in the twenty-four. But nothing tends more certainly to injure the constitution and shorten life, than a want of sufficient sleep,

which is more essential to men of studious habits, and to such as take much laborious exercise, than to the idle and inactive. Owing to imperfection in the nutritive process, sleep is less sound and refreshing in old age, than during the earlier periods of life.

Whatever diminishes the circulation of arterial blood through the brain, and thus impairs its vital activity, tends to produce drowsiness. For example, it is often induced by a full meal, which causes a determination of blood and vital heat from the brain and other organs to the stomach, for the purpose of supplying it with gastric juice, during the process of digestion ; causing sleepiness, languor, and chilliness, in feeble constitutions. Hence the impropriety of taking late and hearty suppers, (especially after a full dinner,) the digestion of which during sleep requires a large supply of blood in the stomach, *at a time that it should be employed exclusively in repairing the previous waste of the solids*, which, as we have seen, is the principal object of repose. For the same reason, (that is, owing to diminished nutrition) sleep is less sound after full than light suppers ; and more of it is required to refresh and renovate the body.

Sleep is frequently induced by a glass of negus or warm spirits and water, which also produce a determination of blood from the brain to the stomach,—and by hearing a dull monotonous discourse, which nearly suspends the train of one's

own thoughts, without being interesting enough to maintain the activity of the brain. Sleep is also induced by exposure to the air of a heated room, which causes a determination of blood to the surface, at the expense of the brain, muscles, and other important organs. Hence it is, that the most delightful of all soporifics is the warm bath, especially after exposure to cold and fatigue, as it removes the stiffness, soreness, and aching, which sometimes prevent sleep when most required. But excessive warmth is unfavourable to sound sleep; first, by increasing the circulation of blood through the brain; and secondly, by raising the temperature of the solids nearly to an equilibrium with that of the arterial blood; by which the combination of its particles with the solids is diminished. Hence it is, that when oppressed with too much covering, we feel languid and unrefreshed on rising in the morning; and that men sleep more soundly in temperate than in hot climates, where nothing more conduces to healthful repose than cooling ablutions, or the tepid bath, before going to bed.

Whatever greatly diminishes the nutritive process, tends to prevent natural sleep, which is therefore always imperfect, if not wholly interrupted during fever, and many other forms of disease. It is also frequently prevented by over activity of the nervous system, caused by mental anxiety and too intense thinking, which interfere with the nutritive process, and induce a feverish

state of the brain, that may be relieved by cold applications to the head, putting the feet in warm water, and then getting into a warm bed—all of which tend to equalize the circulation, diminish the morbid activity of the brain, and thus induce sleep.

It is maintained by Dr. Billing, that a warm bed is favourable to sleep, by causing a *plethoric state of the brain.* (Principles of Med., p. 80.) But according to the observations of Blumenbach, the circulation is diminished in the brain, and its *vessels less turgid* during sleep than when we are awake. Hence it is that strong tea and coffee prevent sleep, by augmenting the circulation and activity of the brain,—or that when the blood is determined from the surface and extremities by sleeping in a cold bed, and sent to the brain in augmented quantities, we are kept awake until the circulation is equalized by warmth. Sleep is more sound during the early part of night, when the nutritive process is actively employed in repairing the previous waste, than towards morning, when it is often partially interrupted by dreams. Long before the philosophy of mind had been rescued from the reveries of metaphysics, by the discoveries of Dr. Gall, it was known that the different senses sleep in succession, and with different degrees of intensity—that in cases of partial somnolency, individuals are capable of hearing, and even of answering questions, when

vision and all the other senses are quiescent—that sleep walkers perform many extraordinary feats of muscular and mental exertion, of which they remember nothing afterwards. But this inquiry cannot be further pursued at present. It may, however, be observed, that nightmare is owing to a temporary obstruction of the general circulation, caused by overloading the stomach, or by the intemperate use of spirituous liquors, both of which prevent sound and refreshing sleep; while they induce a lethargic state of the system, as shown by the torpor of the boa constrictor when gorged with an enormous meal, by some savage tribes, and by nearly all intemperate persons.

As for plants, they require no sleep, because they suffer no loss of their substance and vitality by exercise, therefore, have nothing to do but to grow. The drooping of the leaves which takes place in a few of them when deprived of light, is owing to a diminished circulation of sap through their vessels, and is no more entitled to be regarded as sleep, than the folding up of the leaves that takes place in some plants, under the scorching influence of a burning sun, which causes their fluids to be carried off by evaporation faster than they are supplied by the soil.

Nor must we confound the lethargy of hybernating animals, (during which the temperature falls to that of the surrounding medium, or nearly so, and all the functions of life are arrested or

greatly diminished,) with natural sleep; for what the ancients called the *vital* and *natural* functions, Harvey the *vegetative*, and Bichat the *organic* functions, still continue to go on, while the temperature remains at the healthy standard. But hybernation consists in a diminution or temporary suspension of vitality, which as we have seen is augmented by genuine sleep. Nor must we confound the sweet restorer of nature, and "balm of hurt minds," with the stupor of apoplexy, epilepsy, trance, typhus, and other forms of malignant fever,—all of which are attended with diminished respiration, sanguification, nutrition, and growth. The blood being imperfectly renovated and supplied with caloric in the lungs, becomes of a dark colour even in the arteries, and therefore unfit to maintain the activity of the brain, which falls into what Dr. Billing very aptly terms "the coma of inanition." The same condition is induced by excessive loss of blood, a large abstraction of caloric from the body, the inhalation of mephitic gases, the use of opium, and other narcotics, or by whatever greatly diminishes respiration, the vital properties of the blood, and its power of nourishing the solids.

Influence of the Mind on Health.

Nothing contributes more essentially to health and longevity, than a happy and tranquil state of mind, which must be sought in a temperate exercise of all the physical, intellectual, and moral faculties. Benevolence, friendship, love, a good conscience, with tender, refined, and elevated thoughts, are never failing sources of health and delight; whereas, pride, envy, jealousy, covetousness, anger, and all the passions when habitually indulged to excess, not only embitter our own happiness, and that of all around us, but sap the foundations of health, and shorten the period of existence. It is therefore manifest, that the connexion between vice and misery, virtue and happiness, depends on the radical laws of our organization, which cannot be violated with impunity,—and that a due regulation of the passions is no less important to our well being, than temperance in eating, drinking, muscular exercise, &c.*

* Dr. James Johnson observes in his Treatise on the Economy of Health, that a great majority of our corporeal disorders, in the present state of civilized society, spring from, or are aggravated by mental perturbations,—that the passions are the tempests of life, which too often set at defiance the rudder of reason, driving the vessel on shoals and quicksands, and ultimately wrecking it altogether,—that the bench, the hustings, nay, even the pulpit, pour forth the destructive elements of discord,—that the fury of political strife, the hazards of commerce, the jealousies, envies, and rivalries of the professions, the fear of poverty, the terrors of superstition, and the hatreds of sectarianism, are perpetual sources

That the forces of life are greatly modified by conditions of the brain and nervous system, is evident from the fact, that respiration, on which they all depend, is a voluntary process. Under the influence of hope, love, joy, confidence, and whatever tends to excite pleasurable emotions, the lungs expand with freedom, by which the blood is abundantly supplied with caloric, converted into a bright scarlet fluid, the force of its circulation augmented, digestion, sanguification, nutrition, and all the other functions of life, performed with alacrity. But when the brain is paralyzed by grief, fear, despair, or by the repeated shocks of adverse fortune, the individual almost forgets to breathe, until a feeling of oppression warns him to take a deep inspiration, which is only another name for the boding sigh.

The supply of animal heat by respiration is diminished, the action of the heart enfeebled, the circulation through the lungs and general system is languid, the extremities are cold, perspiration is checked, the surface is pale or sallow, and the

of ill health, and a long train of moral evils,—that nearly all the causes of nervous maladies may be traced to *anxiety of mind, intensity of thought, sedentary avocations, and plenary indulgence*, —that the besetting sin of the present age, is not so much that of intemperance in eating and drinking, as reading and thinking, —the penalty of which, alas, falls far more freqnently on those who labour for the good of society, than on those who live in luxury and idleness. But he adds, of the mode in which the mind operates on the body, we know as little as we do, in regard to the *modus operandi* of gravity and magnetism, (pp. 134—146 —150.)

internal organs are congested with *dark venous blood,* which was called *black bile* by the ancients, who regarded it as the cause of the melancholic temperament. They also knew that happy emotions induce a bright arterial hue of the blood; for Homer speaks of *florid joy,*— and Hippocrates of *black melancholy.* Respiration is no less certainly diminished, and the vital properties of the blood impaired, by the depressing passions, than by the influence of an impure atmosphere, an impoverished diet, too much or too little exercise, intemperance in the use of spirituous liquors, and mercurial salivation, as proved by the experiments of Dr. Prout.

The natural consequence of such a state of things is, that all the secretions are deranged; and the nutritive properties of the blood being diminished, it unites imperfectly with the solids; so that a portion of the caloric which ought to be employed in that process, and in maintaining the secretions, is given out in the free state, causing a low fever, and more or less debility of the brain, stomach, bowels, and of all the organs. In this way is laid the foundation of dyspepsia,*

* The great mistake of Abernethy and many other modern Pathologists, was in supposing that dyspepsia is a primary disease, and that all the complicated symptoms attending it, are owing to sympathy of different parts of the body with some deranged condition of the stomach, which has been aggravated in many thousand cases by the blue pill, black draught, and other pernicious drugs. It is true that the disease is frequently brought

costiveness, hysteria, amenorrhea, low spirits, habitual melancholy, and torpor of all the organs —not, however, because "they are supplied with a vitiated nervous fluid," but because they are supplied with imperfectly arterialized blood, which, as I have already shown, is even more essential to the healthy activity of the brain and nerves, than to that of any other tissue.

In accordance with the hypothetical views of Hoffman and Cullen, Dr. James Johnson tells us, that "the brain presides over *and furnishes energy to every other organ in the body.*" (Op. cit. p. 13.) And Dr. Andrew Combe observes, that "changes in the quality or amount of nervous influence transmitted from the brain to any organ, have a direct power of modifying its function,—that if by some violent emotion of

on by gluttony, and the excessive use of spirituous liquors; but it is much oftener the consequence of grief, anxiety, disappointment, excessive study, want of exercise, exposure to vicissitudes of weather, without sufficient clothing; and, frequently, by the imprudent use of cold drinks. That the proximate cause of the disease depends chiefly on diminished respiration, circulation, secretion, and nutrition, is evident from the fact, that the patient often complains of cold extremities, succeeded by more or less fever, pains in the head, back, and limbs, giddiness, stupor, and general debility, attended with an indisposition of wounds and ulcers to heal kindly, or a diminution of the *vis medicatrix naturæ*—symptoms that obviously require the warm bath, moderate exercise, warm clothing, pure air, nourishing food, agreeable company, with whatever is calculated to augment the circulation, and improve the vital properties of the sanguineous fluid.

fear or grief, the brain be inordinately excited, so as to send forth a stimulus vitiated in quality, the stomach, which receives it, will partake of the disorder, causing the loathing or sickness so often induced by unexpected bad news." (Principles of Physiology, p. 279.)

Many others maintain with Bichat and Richerand, that the organs of digestion, circulation, secretion, &c. are supplied with vital energy by the ganglionic system of nerves. But I have demonstrated in a preceding chapter, that so far as respiration depends on the voluntary action of the brain and medulla oblongata, (exerted chiefly through the *nervus vagus*,) they are essential to the evolution of caloric in the lungs, sanguification, secretion, nutrition, and growth; but no further. Hence it is, that division of the vagus of rabbits causes impeded respiration, a reduction of temperature, and indigestion, as in the experiments of Dr. Philip; while other physiologists have found that it destroys life in a few days. But it was found by Sir Benjamin Brodie, that when the vagus was divided in young cats, near the cardia of the stomach, and below the branch distributed to the lungs, the conversion of food into chyme and chyle was not prevented.

When the mind is overwhelmed with anxiety, grief, despair, or some all absorbing passion, it is no longer capable of exercising its accustomed voluntary power over respiration,—on the due

performance of which, the vital properties of the blood, and the healthy activity of all the functions depend. For it is certain that the life of the brain, spinal marrow, ganglionic nerves, and every part of the body, is derived from the blood, which derives it from the atmosphere, while passing through the lungs. It is therefore manifestly an error to maintain that the brain or any other portion of the nervous system is the source of vitality;—or that they exert any other influence on the vital functions, except through the medium of the lungs.

Nearly the same effects are produced on the constitution of man by intense and long continued study, as by the depressing emotions; especially when the subject of inquiry involves at every step, principles of the widest span, and therefore keeps the intellectual faculties on a perpetual strain.* Hence it is rare to find the highest de-

* The pathological history of literary and scientific men affords innumerable examples of the dangerous consequences arising from over-exertion of the intellectual faculties. No enlightened medical man can read the life and correspondence of Sir I. Newton, without being convinced, that for the space of two years, he laboured under a state of partial insanity, brought on by his excessive devotion to mathematical and physical researches,—aided, perhaps, by anxiety in regard to the extreme narrowness of his income. Had not his labours been rewarded by a lucrative office under government, and crowned with glorious fame, it is probable that he would have sunk into a state of permanent melancholy, if not madness; and have died prematurely of apoplexy or paralysis, which carried off Sir Walter Scott in the sixty-

grees of mental culture conjoined with vigorous health, except among individuals of large thorax. Like the bow which loses its elastic force by being long bent, the power of the strongest mind is gradually impaired by intense thinking. And if not relieved by change of scenery and of occupation,* exercise in the open air, the occasional use of the warm bath, succeeded by a cold douche, light or agreeable amusements, and the soothing conversation of congenial friends, it falls into a state of melancholy, from which it never recovers; or is quenched by apoplexy, paralysis, or madness, still more deplorable than premature death. Alas! how many precious lives have been sacrificed by an ardent zeal to benefit mankind; and some of them while attempting to unfold the laws of physical and moral health. But when

second year of his age; notwithstanding the natural vigour of his constitution. Thus it is that the intemperate quest of knowledge often destroys its favourite votaries no less certainly than the depressing passions, or excesses in eating, drinking, and many other gross vices. But when science shall have been stripped of mystery, and reduced to the simplicity of established principles, it will be only a healthful and delightful amusement to acquire a knowledge of whatever is essential to happiness.

* Change of ideas is as necessary to a perfectly sound state of mind, as variety of food to physical health. Great discoveries may be achieved by the cultivation of a particular talent; but the highest state of mental improvement requires the temperate exercise of all the intellectual faculties and moral sentiments, in such a way as to produce the greatest amount of pleasure without fatigue or satiety, and maintain a due balance of the whole. Otherwise it is impossible to have "mens sana in corpore sano."

the mind has been once kindled with a live coal from off the altar of nature, and inspired with the animating hope of discovering truths more important than mines of silver and gold—it cannot pause in its onward career, until arrested by the approach of death, or the failure of its powers.

It was observed by Madame De Stael, that "grief is not only a foe to intellectual fertility, but a *rapid poison.*" And, like fear, it has been known to destroy life almost as suddenly as a dose of hydrocyanic acid. It also produces epilepsy and apoplexy, which are frequently brought on by over exertion of mind, and depend essentially on a temporary paralysis of the brain, by which respiration is nearly suspended, the power of the heart greatly diminished, and the vital properties of the blood so far impaired, that it becomes black even in the arteries, as shewn by the livid or purple hue of the features. If in this state, the chemical function of the lungs be not speedily restored by fresh air, artificial inflation, or stimulants applied to the nostrils, and the circulation aroused by the application of warmth, aided by friction, the patient sinks to rise no more. For so long as respiration and circulation are suspended, from whatever cause, blood-letting can be of no use.*

* But it is not only by diminishing respiration, and thus impairing the vital properties of the blood, that intense thinking and the depressing emotions, paralyze the energies of the brain, which is weakened by over exertion for the same reason that the volun-

In cases of compression and concussion of the brain, the symptoms are nearly the same as in the worst forms of apoplexy. The breathing is slow and stertorous, the surface and extremities cold, the pulse feeble, with prostration of strength, loss of appetite, nausea, and suppression or derangement of all the secretions. Owing to the vitiated condition of the blood, it fails to unite with the solids,—so that although less caloric is obtained by respiration than during health, it is not transferred to the solids, and expended in maintaining their activity, but accumulates in the body, causing the preternatural temperature of

tary muscles are exhausted by violent exercise. Judging from my own experience during the last five years, I should say that *intense and long continued action of the brain, has a direct tendency to impede the nutritive process, by which its composition and power are perpetually renovated.* For I have observed in very many instances, after a few hours severe application, (especially when the general strength was much reduced,) that the forehead became feverish, and hotter than any other part of the body,—shewing that the caloric sent to that organ, in combination with arterial blood, was not all employed and expended in maintaining the renewal of its substance and vitality. At such times, the circulation through the brain was so far impeded as to cause a preternatural throbbing of the carotid arteries; and the loss of mental power was often such as to prevent all successful exertion; but was uniformly more or less restored by the application of cold water to the head, moderate exercise in the open air, and the conversation of agreeable company. The most effectual method of prosecuting any literary or scientific enterprize which requires intense application, is to pursue the subject at leisure, so as never to induce exhaustion of the nervous system.

fever. Nor can the fevers thus induced be easily distinguished from such as are brought on by the influence of cold, miasmata, filth, and a vicious or poor diet; but present the typhoid or inflammatory type, according to the greater or less injury of the brain, state of the constitution, &c.

It has been long known that during the prevalence of epidemics, fearful and desponding individuals, like those who have been weakened by intemperance, poor living, cold, impure air, and exhaustion from too much labour, are among the first to be attacked, and the most difficult to cure. Nor is there anything in the whole materia medica so potent in the prevention and cure of disease, as a buoyant state of mind. And it is certain that a better knowledge of nature, as connected with the laws of health, would banish much of the idle terror that prevails among the people; and which is too often fostered by their spiritual leaders, who ought to know that despair of recovery is the beginning of death.

In those cases of partially suspended animation, termed trance, which occur chiefly in persons of weak or disordered minds, especially females of irritable constitution, the brain is paralyzed by over excitement of the nervous system, caused by religious emotions of ecstasy, fear, &c. Respiration is so far arrested, that the temperature of the patient has been known to fall 20° or 30° below the natural standard, when

the action of the heart becomes almost extinguished, the surface pale, and the individual exhibits scarcely any appearance of life. In many respects, the phenomena resemble the effects produced by the influence of what has been termed animal magnetism. After mesmerizing about 100 persons of different classes, and both sexes, Dr. Sigmond states, that he found females much more easily affected by his manipulations than males ;—that in some, they brought on sleep, or stupor—in others, fainting, hysteria, convulsions, and even trance ;—that respiration became imperceptible, the pulse feeble, the extremities cold, and the features pallid ;—that in the case of a young lady in Fitzroy Square, it induced all the symptoms of suspended animation, which lasted four hours.* (Lancet, Dec. 9, 1837.)

* Dr. Sigmond very justly refers the phenomena to diminished respiration ; for he says, "the principle is precisely that of stealing the breath away." Yet he maintains, that "the act consists in obliging the person to breathe again the carbonic acid previously expired." But this theory is quite as satisfactory and explicit as that of John Hunter, who defines trance as "the natural effect of a disposition in the person to have the action of life suspended for a time." (Obs. on the An. Economy, p. 109.) All such cases should be treated by first arousing the circulation by artificial respiration, the warm bath, friction, sternutatories, and afterwards prevented by avoiding the exciting causes,—not excepting the manipulations of mesmerism, which cannot fail to derange the healthy state of the nervous system in weak females.

The advocates of Mesmerism admit, that trance, sleep walking, catalepsy, and other similar affections of the nervous system, are

The function of respiration is diminished by swinging, whirling round, or riding backwards in a carriage, which interferes with the voluntary power of the brain, causing giddiness, weakness, nausea, and sometimes fainting. Nor is it more

modifications of the same influence; and that it cannot be produced on persons in a state of vigorous health and sound mind.

But as Dr. Paris justly observes, "a propensity to attribute every ordinary and natural effect, to some extraordinary and unnatural cause, is one of the striking peculiarities of medical superstition." (Pharmaclogia, vol. i. p. 17.) And it was said by Becquerel, that whatever has been found most difficult to comprehend, men have latterly referred to electricity,—which has been supposed to be the cause of animal magnetism, and capable of enabling people to see without the organs of vision, to predict future events, and to perform many other miracles. Yet we are told by Menzel, that "the discovery of animal magnetism is certainly one of the most important that was ever made, and does *especial honour to Germany*,"—while he ranks the great discoveries of Gall along with "the foolery of Lavater." (German Literature, Vol. II. p. 218.) That no material agent or fluid is communicated from the operator to the patient, has been repeatedly demonstrated by the fact, that no impression is produced when the process is performed without his knowledge, or upon young children, who are unconscious of what is done. And that many of the cases on record are gross impostures, has been shown by making patients believe that they were mesmerized, when nothing of the kind was done, and thus producing all the pretended effects, without any intervention of the assumed cause; and by the counter experiment of performing upon them the magnetic process without their knowledge, when no effect was produced. It is therefore obvious that all the phenomena are resolvable into impressions made on the nervous system, or into operations of the mind, like the visions of Swedenborg, and other dreamers of disturbed imagination.

strange that the passes of the animal magnetist should induce sleep, fainting, and catalepsy, than that the rocking of a cradle should put children to sleep. Dr. Wollaston informs us, that while at sea, he caught himself holding his breath, as if waiting till the lurch of the vessel was over. And he very justly referred the languid action of his pulse, the great prostration of strength, together with the nausea and vomiting, to the influence of the ship's motion on the function of respiration.

In feeble and irritable constitutions, the chemical function of the lungs is greatly diminished by painful impressions made on the nervous system. It is well known that compound fractures, extensive burns, painful surgical operations, and protracted labours, or even a painful prick of the hand or foot, are often followed by coldness of the skin, weak pulse, livid countenance, faintness, stupor, general prostration of the system, convulsions, and sometimes by death in a few hours. Many of the above symptoms have been caused in children by the irritation of teething, worms, and the presence of indigestible matters in the stomach; but much oftener by inflammation of the glottis, which impedes the passage of air to the lungs, and destroys life by suffocation.

Modus Operandi of Medicinal and Morbific Agents.

It is still a question among physiologists, whether these agents operate primarily on the blood, or through the medium of the nervous system, by what has been called sympathy, as maintained by Stahl, Hoffman, Baglivi, Gaubius, Cullen, Brown, and a large majority of modern pathologists. That the brain and nervous system are more quickly and powerfully affected by the mephitic gases and narcotic poisons than any of the other organs, cannot be denied. But we have already seen that all parts of the body are formed from, and vitalized by, the blood, which is absolutely essential to every operation of the animal economy, and more essential to the healthy activity of the brain than any other part of the system,—consequently, that whenever the vital properties of the blood are impaired, the nervous system is the first which becomes diseased.*

It was long ago ascertained by Fontana, that opium, poisons of the viper, ticunas, and laurel

* For example, we have seen that about five times more blood is sent to the brain, in proportion to its weight, than to the body in general. The consequence of which is, that it is the first organ to suffer from loss of blood, or from whatever impairs its vital properties. Hence the prevalent opinion of pathologists, that the remote and exciting causes of fever produce their primary effects on the nervous system.

berry, exert only a local influence on the nerves, and produce no general effects unless they enter the circulation. Sir Benjamin Brodie also found, that when the woorara poison was applied to a wound in the fore foot of a rabbit, after all the nerves of the anterior extremity in the axilla of the same side were divided, the action of the poison was not prevented: but that when a ligature was placed around the leg of a rabbit, leaving out the principal nerves, no bad effects were produced by the poison, until the ligature was loosened, when they immediately ensued. (Phil. Trans. 1811, p. 178; 1812, p. 107.) He also found, that muriate of barytes, tartar emetic, and corrosive sublimate, produced the same effects when applied to fresh wounds as when taken into the stomach,—that, like arsenic, alcohol, oil of tobacco, oil of almonds, and other narcotic poisons, they are absorbed into the circulation, and produce their morbid effects by diminishing the voluntary power of the brain over the function of respiration. He further ascertained, that after respiration and all the visible actions of life in a rabbit had been arrested by a dose of the essential oil of almonds, they were restored by keeping up artificial respiration for sixteen minutes, and the animal appeared perfectly well in two hours.*

* We are informed by Mr. Morgan of Guy's Hospital, that Mr. Sewell of the Royal Veterinary College inoculated a horse suffering from an attack of locked-jaw, in the fleshy part of the

In accordance with the foregoing facts, we are informed by Müller, that in the experiments of Wedemeyer, the strongest prussic acid produced no sudden effect when applied to the nerves so as not to enter the circulation :—that when Emmert amputated the extremities of animals, leaving them connected with the trunk by the nerves only, and then introduced poison into the feet, no general effect resulted ; nor even when applied to the nervous trunks themselves :—that Viborg

shoulder, with an arrow point coated with the ticunas, (which has been supposed to have the property of paralysing the voluntary muscles, and thus of arresting spasmodic action,) when apparent death was produced in ten minutes; but that on keeping up artificial respiration four hours, re-animation so far took place, that the animal rose up, seemed perfectly recovered, and eagerly partook of hay and corn, without any return of tetanus; yet died the next day. Mr. Morgan relates the case of an ass affected with tetanus, that was treated in the same way, with similar results; from which he was induced to recommend inoculation with the ticunas as a remedy for tetanus. But as it is certain, that nearly all the active poisons produce convulsions, I am fully convinced that, in the above cases of tetanus, the relief arose from the employment of artificial respiration, *in spite of the deadly poison:* for it will be shewn hereafter, that in all the worst forms of tetanus and hydrophobia, the natural process of respiration is nearly suspended. I am the more disposed to attach the highest importance to artificial respiration, aided by the warm bath, in all spasmodic diseases, from the fact that they are always attended with difficult respiration, and a dissolved or greatly vitiated state of the blood, which is the proximate cause of all the most fatal forms of disease, and should be counteracted by restoring the process of respiration, by which the blood is formed and purified.

applied nearly a dram of concentrated prussic acid to the brain of a horse, laid bare by means of the trephine, without the slightest symptoms of poisoning being produced:—that Magendie and Delille divided all the parts of the thigh of a dog, except the crural artery and vein, which were dissected quite clean, and freed from their cellular coat, to maintain the connexion of the limb with the trunk—when two grains of the upas ticuti were inserted into a wound in the foot, the action of which was as rapid as if the limb had not been previously injured,—the first symptoms showing themselves in four minutes, followed by death in ten minutes.

We are therefore bound to admit with Müller, that the general effects of poisoning are produced by the entrance of noxious substances into the circulation, through which they operate upon the brain and nervous system.* He further states,

* A still more decisive proof that poisons operate on the solid tissues through the medium of the fluids is, *that they destroy the life of plants, which have no nervous system*, as when they are placed in air containing small proportions of sulphurous, nitrous, or hydrochloric acid, ammonia, carbonic oxide, olefiant gas, or in solutions of the vegetable, animal, and mineral poisons. This has been fully demonstrated by the experiments of Macaire, Turner, Christison, and other physiologists; who have also found that the *Mimosa Pudica* and the *Berberis Vulgaris* are killed much sooner by hydrocyanic acid than by solutions of opium, corrosive sublimate, arsenic, and arseniate of potash. But as the circulation of plants is less rapid than that of warm blooded animals, so does it require a longer time for poisons to extinguish their vitality.

that on applying narcotics to the spinal marrow and nerves of frogs, no twitching of the muscles was excited, unless the poisons entered the circulation; yet he thinks their local action on the nervous system is proved by the influence of belladonna in dilating the pupil of the eye, and of lead in causing paralysis of the hands. (Elements of Physiology, pp. 238—242—628.)

That poisons operate on the nervous system through the blood, might naturally be inferred from the fact, that their effects are produced more rapidly on birds than mammalia, and very slowly on cold blooded animals, or whenever the circulation is languid, as in cases of nearly suspended animation from cold, or by inhaling carbonic acid. For example, it was long ago observed by Dr. Horsefield, that when fowls were wounded by arrows dipped in the chettik of Java, they died in one minute; and that much depends on the size of the animal; for when large, the poison is more diluted than when it is small:—that the poison of the upas killed a mouse in ten minutes, a cat in fifteen minutes, a dog in one hour, and a buffalo in two hours ten minutes.* Similar results were obtained by Brodie, who also found that the narcotic poisons operated sooner on the brain, and thus arrested respiration,

* It was also found by Thenard, that the respiration of air containing $\frac{1}{1500}$ its volume of sulphuretted hydrogen destroyed the life of birds, $\frac{1}{300}$ that of dogs, and $\frac{1}{250}$ that of the horse.

when applied to the tongue, than to the intestines, and sooner in small than large animals.

Müller relates, that Hering found from eighteen experiments on horses, that ferrocyanate of potash mixed with the blood passed from one jugular vein, through the lungs and general system to the opposite jugular vein, in from 25 to 30 seconds,—from the jugular vein to the great saphena in 20 seconds,—from the jugular to the masseteric artery in from 15 to 30 seconds,—to the facial artery in one experiment in from 10 to 15 seconds,—and from the jugular vein to the metatarsal artery in from 20 to 30 seconds. Müller also states from his own experiments, that coloured fluids pass through living membranes in one second, so as to be seen on the opposite side; and he thinks that the speedy effects of hydrocyanic acid are owing partly to its elasticity, by which it is rapidly diffused, absorbed into the circulation, and thus conveyed to the brain and spinal marrow.

Mr. Blake has further shown, in a paper published in the Med. and Surg. Journal, vol. 53, and another in the Lond. Med. Gazette of June 18, 1841, that the rapidity with which poisons operate is in proportion to the activity of the circulation, and the nearness of their application to the nervous centres:—that hydrocyanic acid never produces its first symptoms sooner than 9 seconds:—that one grain of strychnia dissolved in a small quantity of acetic acid, produced con-

vulsions in 20 seconds, when injected into the jugular vein of a dog, and apparent death in 90 seconds:—that woorara arrested the action of the lungs, and caused apparent death in 25 seconds, when introduced into the jugular vein:—that convulsions and death followed the insertion of conia into the femoral vein of a dog in 30 seconds: —and that, in another dog, hydrocyanic acid passed from one part of the vascular system back to the same part in from 12 to 20 seconds.

When the narcotic poisons do not immediately destroy life, they produce small and difficult respiration, coldness of the surface, weak pulse, a pale or livid and ghastly expression of countenance, drowsiness, stupor, nausea, and sometimes vomiting; a dark and dissolved condition of the blood, prostration of strength, convulsions, and nearly all the symptoms which follow the inhalation of mephitic gases, or an excessive loss of blood. And that they all operate by entering the circulation, is evident from the fact, that they rapidly disappear from a shut cavity, after which they are found in the blood and various secretions. It has also been fully established by the numerous experiments of Magendie, Orfila, Thackrah, Dr. John Davy, Prater, and other physiologists, that, when sufficiently concentrated, they greatly diminish the coagulating property of the blood, by dissolving its fibrin, or by disorganizing its red particles,—that after death, the lungs, brain, and abdominal organs are found engorged with

dark fluid blood, and the body soon putrefies. It is therefore evident, that if in small doses they alleviate pain, it is owing chiefly to their influence in diminishing sensibility, by impairing the vital properties of the blood;—that if hydrocyanic acid relieves pain in the stomach, it is by inducing torpor of that important organ; and so of all the other narcotics.*

* The influence of alcohol is very similar to that of opium and other narcotic poisons. It kills leeches in two or three minutes, and very soon destroys the life of plants. Like the strong acids and caustic alkalies, it produces rapid inflammation of the stomach, solidifies the albumen of the blood, arrests the process of breathing, and causes all the symptoms of apoplexy, as proved by the experiments of Brodie on cats, rabbits, and dogs. Orfila found that the injection of four drams of pure alcohol into the veins of a dog was followed almost immediately by death. And that it impairs the vital properties of the blood when diluted, as in the form of spirits, wine, or even malt liquors, is evident from its dark, grumous character, and diminished power of coagulation, when drawn from the veins of a drunkard. The consequences of which are diminished respiration, cold extremities, and shivering from slight exposure, (when the influence of the stimulus has ceased,) a dirty or livid complexion, loss of appetite, impaired sensibility, torpor and congestion of the capillaries, attended with palpitation of the heart, imperfect nutrition, low spirits, giddiness, stertorous breathing, confusion of mind, softening of the brain, premature old age, sterility, madness, idiotism, epilepsy, paralysis, apoplexy, and death. Delirium tremens, the most common disease of drunkards, comes on with chilliness, weak pulse, nausea, great mental depression, general debility, and a cadaverous expression of countenance, followed by imperfect sleep, frightful dreams, a dry and furred tongue, cold sweats, tremors, convulsions, and sometimes death. Mr. Lay also describes the Chinese opium-eater as marked by a sallow visage, weak voice, ghastly features, emaciated limbs, and tottering gait.

Arsenic also, when applied to a fresh wound, or taken into the stomach, causes short and hurried respiration, coldness of the surface, a pale or livid hue of the face, feeble pulse, vomiting, faintness, stupor, convulsions, and death, when the stomach is found to exhibit decided marks of inflammation. In doses of from $\frac{1}{8}$ to $\frac{1}{16}$ of a grain, three or four times a day, it has been often observed to produce nausea, vomiting, griping pains, head-ache, sweating, tremors, spasms of the lower extremities, cutaneous eruptions, and other symptoms of constitutional derangement. It should be banished from the Materia Medica. The effects of red or white lead when taken into the stomach are diminished respiration, coldness of the extremities, small and slow pulse, nausea, cramps, torpor of the bowels, prostration of strength, partial paralysis, convulsions, and death. The salts of copper are also followed by rigors, violent head-ache, loss of sensibility, vomiting, cramps, paralysis, and death.

Corrosive sublimate produces nearly the same effects as arsenic, with still more decided marks of inflammation in the stomach. Like the chloride of tin, the hydrochlorate of baryta, the subacetate of lead, the nitrates of copper and bismuth, it combines with, and precipitates the albumen of the blood, according to Magendie, who recommends the white of eggs as an antidote when any of these poisons have been swallowed. He also found that seven grains of oxalic acid,

when injected into the veins of a dog, caused difficulty of breathing, followed by death the next morning, when his blood was found in a dissolved state, as when mixed with the same poison out of the body. But a larger quantity is required to produce the same effects when taken into the stomach, because it is then more gradually diffused throughout the mass of the blood, and thus diluted. When half an ounce is swallowed, respiration is greatly diminished, the surface becomes cold and clammy, the pulse feeble or imperceptible, the countenance pale or livid, attended with nausea, vomiting, convulsions, and death in a few hours, when the stomach is found in a state of inflammation.

Tartar emetic produces vomiting, purging, great debility, head-ache, and often cramps, whether taken into the stomach, or applied to a fresh wound. Magendie found that when from six to ten grains of it were introduced into the stomach of dogs, and the gullet tied, they died in from two to three hours:—that when a solution of it was injected into the veins of a dog, it produced nausea after the stomach was removed, difficulty of breathing, cough, symptoms of pneumonia, fever, and death. He further states, that he has not found the exhibition of this medicine, in the treatment of pneumonia and rheumatism, to correspond with the accounts of Læennec:—and that when mixed with very small proportions of blood,

immediately after it was drawn from the body, it disorganized the red particles. We are also informed by Andral, that when six grains of it were given daily in divided doses to individuals labouring under the milder forms of pneumonia, the disease gradually assumed the character of malignant typhus. And there is reason to believe that, if all physicians had recorded their observations with the same intelligence and fidelity, many thousand similar cases might be adduced.

The operation of an emetic is attended with all the leading symptoms of intermittent fever. Its first effect is to weaken the capillary vessels of the stomach, by impairing the vital properties of the blood ; to arrest the secretion of gastric juice, and cause a tendency to inflammation of that important organ. The shock thus imparted to the general system, diminishes, to a greater or less extent, the function of respiration, as shown by a slight sensation of chilliness soon after the medicine is taken, followed by a small, frequent, and irregular pulse, head-ache, dimness of vision, lowness of spirits, and universal debility, until a spasmodic state of the stomach is induced, and its contents are discharged by vomiting. But as this stage of depression is attended by a cessation of nutrition and of all the secretions, the vital heat obtained by breathing is not transferred to the solids, but accumulates in the blood, causing

a temporary fever: for it was found by Dr. C. Holland, that soon after it produces vomiting, the temperature under the tongue is about 2° above the healthy standard. This elevation of temperature augments the action of the heart, by which the blood is sent into the extreme capillaries of the whole body, and perspiration induced, when the paroxysm terminates, and the various functions gradually return to their former state.

Thus we perceive that tartarized antimony (and the same is true of all other emetics) produces, in a mitigated form, and for a short time, the *cold*, *hot*, and *sweating stages* of intermittent fever; consequently, that it operates in the same way as malaria and other morbific agents. It is, therefore, not surprising that, when given in small doses for several days in succession, it generates malignant typhus, as proved by the experiments of Andral, and other pathologists.* But if the object be to excite perspiration, why

* It is obvious that when tartar emetic is taken in large doses, it is less dangerous than in smaller ones, because, in the one case, the greater part of it is soon expelled by vomiting and purging; whereas in the latter case, it is nearly all absorbed into the blood, the red particles of which it dissolves, and thus impairs its vital and nutritive properties. We have already seen, that when only six grains were introduced into the stomach of a dog, and the œsophagus was tied, so as to prevent its expulsion, death was produced in three hours. What then can justify the practitioner who gives his patient from two to six grains of this medicine daily, in broken doses?

employ a medicine that does so by impairing the vital properties of the blood, and by generating more or less fever? Is not caloric the most certain, agreeable, and salutary of all the sudorifics and diaphoretics, when employed externally and internally? Does it not increase the vigour of the circulation through the lungs when torpid, and thus improve the vital properties of the blood? Is it not the agent on which all the phenomena of life and health depend? Why then resort to the use of a drug, the obvious tendency of which is to diminish all the powers of life,—except when it is necessary to relieve the stomach from an accumulation of morbid or indigestible matter?

Perhaps there is no article in the Materia Medica that has been more extensively employed than the various preparations of mercury, which, there is reason to believe, has destroyed more constitutions than even malaria; for, although the mode of its operation is still involved in mystery, it is given in almost every form of disease. It has long been regarded as a specific remedy in syphilis; but, fortunately for mankind, physicians are now beginning to learn that this disease may be cured without mercury; and that it rarely proves dangerous, except when aggravated by the abuse of that mineral, to which the worst forms of what has been called secondary syphilis are now justly ascribed.

It was the opinion of John Hunter, that mer-

cury cures syphilis by creating another disease, which, being incompatible with the primary one, overcomes and removes it. But this is obviously no explanation. And there is reason to believe, that it operates either by combining with and neutralizing the syphilitic virus, or by diminishing the nutritive process, and thus enabling the absorbents to remove chancres, buboes, and other glandular enlargements. Dr. Billing maintains very justly, that both mercury and iodine remove morbid growths by starving them.* In favour of this opinion, it is well known that tartarized antimony, and other emetics, (which operate by

* In a late Treatise on the Mercurial Disease, by Dr. Dietrich of Munich, we are informed that it is attended with a sensation of coldness, which is followed by alternations of feverish dryness and profuse sweats, with salivation, a dissolved condition of the blood, great prostration of strength, diarrhæa, hemorrhages, and cold sweats,—when mercury may be detected in all the secretions, or by rubbing against the skin a piece of copper, which becomes white:—that if not carried out of the body through the different emunctories, it produces ulceration of the soft parts, and swelling of the bones, or disease of the periostium:—that the worst forms of the disease are attended with softening of the brain, paralysis, apoplexy, madness, or loss of mental power, dropsy, rapid emaciation, subsultus tendinum, hectic fever, and death. Alas! how many thousand lives have been sacrificed by the abuse of this slow but certain poison! Nearly the same fatal effects are produced by the long continued employment of iodine, which sometimes causes vomiting, purging, small pulse, fever, cramps, colic, rapid emaciation, and death, when it is found in the blood, milk, and urine of the patient. We are also informed by Orfila, that four grains of iodide of potassium, when injected into the jugular vein of a dog, caused convulsions and death in about one minute.

arresting or diminishing the nutritive process,) cause the removal of buboes, swelled testicle, effusions of lymph, serum, &c.

The general opinion is, that mercury, iodine, digitalis, and some other medicines, produce these effects by augmenting the activity of the absorbents; whereas they operate by diminishing the process of nutrition, while that of absorption continues to go on; causing a more or less rapid waste of the whole body, by which effusions and morbid growths are removed.* It is in this way that small doses of calomel have been supposed to be useful in removing the effects of chronic inflammation of the larynx, trachea, and bronchi, —which is often attended with an effusion of lymph, and a thickening of the mucous mem-

* It is maintained by medical authors of high repute, that salivation is useful in fever, by preventing the nutritive process. But I have proved that the proximate cause of fever, and in reality of all the other forms of disease, is a derangement of the nutritive process; and we have just seen that the use of mercury induces hectic fever. Why then give a medicine which produces the very symptoms we wish to counteract and remove? Yet there is reason to believe, that when given in four grain doses every four hours through the day, and followed by some more brisk cathartic, calomel is an excellent remedy for the removal of morbid excretions from the alimentary canal. I cannot, however, subscribe the prevalent doctrine of the schools, that it increases the secretion of bile,—an opinion which seems to have arisen from the fact, that, like many other medicines and morbific agents, it arrests or greatly diminishes the process of digestion; so that there is but little chyme formed to unite with the bile, which, therefore, seems to be more abundant than usual.

brane. Thus it is by giving a preponderance to the lymphatic absorbents over the nutritive process, that such medicines produce their effects. Nor can there be a doubt that nearly all the more active articles in our Materia Medica impair the vital properties of the blood, and, relatively, increase absorption.

For example, it was found by Orfila, that by injecting a dram of the liquor ammoniæ into the jugular vein of a strong dog, convulsions immediately followed, and death in ten minutes. The same effects are produced in a much shorter time by injecting a few grains of caustic potash into the veins of a dog. Liebig maintains that alcohol, and most of the neutral salts, operate by abstracting water from the moist tissues. But we have seen from the experiments of Magendie, (referred to in a note to pages 653-4 of this work,) that, when mixed with fresh blood as soon as taken from the body, they all destroy or greatly retard its coagulation. He also found that very small proportions of carbonate of soda, carbonate of potash, carbonate of ammonia, nitrates of potash, lime, and other alkalies, produced the same effects:—that soon after injecting less than an ounce of carbonate of soda into the veins of a dog, he was attacked with dyspnœa, small and frequent pulse, prostration of strength, congestion of the lungs and abdominal viscera, effusions of blood, and all the symptoms of malignant

typhus fever.* It is, moreover, certain, that when taken into the stomach daily in small doses for a considerable time, they induce great emaciation, a dissolved condition of the blood, and many of the symptoms that characterize scurvy. Many of them operate as diuretics merely from their refrigerating influence, by which perspiration is checked, and the amount of urine proportionally augmented. But when taken with hot drinks, they sometimes operate as diaphoretics.

From the foregoing brief and imperfect examination of this important subject, it is evident that nearly all the most active articles employed in the treatment of diseases are more or less hostile to the animal economy, as maintained by many of the most enlightened physicians of ancient and modern times. There is reason to believe that the prevalent abuse of emetics and purgatives has been owing in part to the erroneous opinion of the Greeks, that the proximate cause of fever and other forms of disease is a superabundance of bile, which ought to be carried off.

* Magendie further ascertained that, by introducing a portion of finely powdered potato starch into the carotid artery of a dog, he was attacked with dyspnœa, cough, prostration of strength, diarrhœa, and fever:—that when he injected a dram of varnish, holding some sifted pulverized animal charcoal in suspension, into the femoral artery of another dog, after tying it, the limb became swoln below the ligature, cold, motionless, and insensible, followed by extravasation of blood into the cellular tissue, obstruction of the capillaries, and gangrene.

Yet Hippocrates often cautions us in regard to their debilitating influence, especially in acute diseases, and during the relaxing heat of summer. He further states, that in some cases the death of his patients seemed to be hastened by the violent operation of the medicines which he prescribed.* (Epidemics, book v.)

It was wisely observed by Celsus, that "*medicine is not always good for the sick, but invariably hurtful to the healthy.*" And it was maintained by Asclepiades, that "*diseases should be cured quickly, safely, and pleasantly.*" But we have seen that a very large majority of our medicines operate as predisposing and exciting causes of disease, by deranging the nutritive properties of the blood, weakening the stomach, bowels, brain, voluntary muscles, and depressing all the powers of life; consequently, that they cannot always be given *safely*. And it must be admitted, that so far from being *pleasant*, most of them are extremely nauseous and disagreeable.

After devoting a long life in endeavouring to improve the profession of medicine, the celebrated Hoffman laid it down as an axiom—

* And it was maintained by Plato, that "the very existence of physicians in a republic is a proof of vice among the people." But does not the same observation apply equally to the other learned professions, and still more strongly to that of war? Yet they are necessary evils in the present imperfect state of society, and must continue until a higher and better state of knowledge shall become the universal inheritance of mankind.

"avoid drugs and physicians, if you value your health." There is a still more severe satire on the Faculty, by one of its own fraternity, in the following lines of Faustus by Goëthe:—

"Thus with our hellish drugs, death's ceaseless fountains,
In these bright vales, o'er these green mountains,
Worse than the plague we raged:
I have myself to thousands poison given,
And hear their murder praised as bless'd by heaven,
Because with nature strife he waged."

Even Dr. Cullen tells us, in his work on the Practice of Physic, that a purge often brings on a relapse of intermittent fever, after the paroxysms had ceased. The doctrine of Broussais, that all fevers depend on inflammation of the stomach and bowels, was partial and erroneous; yet it had the good effect of lessening the use of emetics and purgatives, which, although sometimes useful in removing morbid accumulations, often aggravate the disease.* And although the Homœopathic theory be founded on a series of hypotheses that

* The late Dr. M'Culloch was still more opposed to the use of emetics, cathartics, and other active medicines, which together with blood-letting, he ranks among the principal causes of disease. And Dr. James Johnson observes, that "in a great majority of the mild fevers in temperate climates, it is probable that nature would be more successful than art, or the farrago of medicines prescribed by the routine practitioner." But he facetiously adds, "let not this, however, be told in Gath." And he very properly ridicules the prevalent self-quackery of taking calomel, or some other mercurial preparation, for the removal of what is called *biliousness*.

explain nothing, the infinitesimal doses of medicine which it prescribes are harmless, and afford nature an opportunity of curing the disease. Yet its votaries are chargeable with leaving undone many important things which ought to be done.

In a practical point of view, *caloric*, *air*, and *food* are of infinitely more importance, in the prevention and treatment of diseases, than all the articles of the Materia Medica; because they are the natural agents by which all the healthy operations of life are maintained. Next to these, are the artificial stimulants, such as wine, spirits, æther, ammonia, the essential oils, balsams, spices, and terebinthenites,—all of which owe their active properties to the large amount of caloric which they contain, as shown by the hot and burning sensation they produce in the mouth and stomach. Hence it is that, when the powers of life are reduced below par, they are often useful in restoring the circulation to its natural vigour.

It is also worthy of notice, that the stimulating influence of the Spanish fly, mustard, turpentine, pitch, and many other external applications, is owing chiefly, if not wholly, to the heat which attends their operation. It has been generally supposed that blisters and rubefacients relieve internal inflammations and congestions by acting as revulsives and evacuants. But the same beneficial effects are produced by the permanent application of a heated iron or vessel of hot water, without any evacuation of serum and lymph. I

am therefore inclined to believe, that they operate by augmenting the partially suspended circulation of the capillaries, which is the proximate cause of inflammation. As for the balsams, they stimulate the mucous membranes, which, in chronic catarrh and gonorrhæa, are in a weakened state.

The opinion of Cullen, that Peruvian bark and other tonics render the tissues more firm, and augment their cohesion, has been rendered highly probable by the researches of Dr. Adair Crawford, who maintains, in his " Experimental Inquiry into the Effects of Tonics," that their operation is chiefly mechanical, and owing to their astringent properties. Should it be objected that alum, acetate of lead, and many other astringents, are greatly inferior as permanent tonics to the cinchona, other bitters, pepper, and spices ; I answer, that the former operate as poisons, and gradually impair the vital properties of the blood ; whereas the latter remedies do not produce this effect. It is consoling to find that the most agreeable of all remedies are the most speedy, efficacious, and safe, in the prevention and treatment of diseases. For example, what is so pleasant and effectual in arresting and preventing the chilliness by which they are all ushered in, as the warm bath, hot drinks, and the application of dry heat? or when the temperature has been raised above the natural standard, what so delightful and salutary as fresh air, with cooling drinks and ablutions?

CHAPTER IV

Theory of Temperaments.

"The moderns have neither by observation extended the ancient distinctions of temperaments, nor, though they have attempted it, have they ever given, as far as I can judge, any happy explanation of the causes or foundation of the distinctions they have so generally adopted." CULLEN.

It was maintained by the great Hippocrates, that the vital spirit or soul, (ψυχη,) is the same in all men, and in every description of animals,—that as death is always produced by excessive hemorrhage, the soul resides in the blood :—that all diseases are essentially the same, modified, however, by climate and season, air and food, age, sex, conditions of the mind ; and are always owing to some derangement of the soul, which he also termed πνευμα, θερμον, and φυσις :—that all organized bodies are composed of four primitive elements, which are endowed with inherent properties of heat, cold, dryness, and moisture,—that all the varieties of constitution in man, whether in a state of health or disease, depend on the predominance of one or more of what he called the four cardinal humours ; viz, red blood, yellow bile, black bile, and phlegm ; giving rise to the sanguine, choleric, melancholic, and phlegmatic temperaments.

He maintained, that these four primary humours were all specifically different from each other in temperature, colour, consistence, &c.;—that red blood is hot and moist; yellow bile hot and dry; black bile cold and dry; phlegm cold and moist,*—that when the elements and humours were duly mixed, the constitution was perfect, and the tendency to disease in proportion to the deviation from this balanced mixture, *κρασις*, or *temperamentum*. (De Nat. Humana, 5, 6.)

That the phlegm of Hippocrates was not merely the secretion termed mucus, but included

* In the Treatise *De Structura Hominis*, he maintains that red blood predominates in spring, because it is then often discharged from the nose spontaneously; and that it is warm and moist because the season is so:—that yellow bile superabounds during summer, because it is then frequently vomited spontaneously; and like the season was hot and dry, therefore the cause of fevers:—that black bile predominated during autumn, being cold and dry, because the season was so; and during old age, which he regarded as the autumn of life, when the blood is watery and impoverished, causing a predisposition to melancholy and sadness. (Epidemics, Lib. vi. Sect. 1, 2.) Finally, he supposed that phlegm was cold and moist, because, during winter, when the atmosphere is cold and moist, it is more abundant than at any other season; and as it is discharged from the lungs or throat during catarrh, influenza, pneumonia, phthisis, &c. he regarded it as the predisposing cause of those diseases. All this is very absurd and fanciful; for although it be true, that all diseases of the respiratory organs are more prevalent during winter than summer, and the secretion of mucus or phlegm more copious; they are merely concomitant effects of cold. In like manner, the excess of bile and the prevalence of fevers during summer, are merely effects of an elevated temperature, impure air, and other causes that arrest or diminish digestion, and the formation of chyme.

the serous portion of the blood, would appear from the fact, that he describes it as the humour from which urine, sweat, and dropsical effusions are derived. Whether he always meant by yellow bile the hepatic secretion is doubtful; for although he says that it is found in the liver, he states in another place, that on dissecting the heart of an animal, he found a little *yellow bile* in the left ventricle. (De Corde, Sect. 9.)

But that his black bile was identical with dark venous blood, is evident from the fact, that he supposed it to be generated in the spleen, which is now well known to be a reservoir of black blood. And he states that the dark grumous fluid discharged from the stomach in cases corresponding with our hematemesis, was black bile. (De Morbis. Lib. II.) Accordingly, it was regarded by Hoffman, Morgagni, Cullen, and many other distinguished moderns, as only another name for dark venous blood. Nor can there be a doubt, that in a climate like that of Greece, respiration is so far diminished by the excessive heat of summer and autumn, as greatly to impair the vital properties of the blood, and change it to a darker colour than usual.

From the time of Boerhaave to that of Richerand, physiologists have described the sanguine temperament as marked by a broad chest, full and robust body, strong pulse, an abundance of rich arterial blood, a florid complexion, a cheer-

ful flow of spirits, and a vigorous exercise of all the functions, with an elevated temperature. They also represent the choleric temperament as marked by a broad chest, a high temperature, a spare but muscular frame, an active circulation, great mental power, and a passion for lofty achievements—attributes which have no more connexion with the size of the liver and the quantity of its secretion than with the amount of urine or of cutaneous perspiration. And if it be true that the quantity of good arterial blood is in proportion to the magnitude and soundness of the lungs, it is evident that the choleric is only a modification of the sanguine temperament. And if it be true that the intellectual endowments of men are in proportion to the magnitude of the brain, *ceteris paribus*, it must be more fully developed in such as belong to the choleric temperament, which is characterized by strong passions, aspiring ambition, and great energy of mind. It is therefore obvious, that the bilious temperament is a mere phantom, which should be henceforth excluded from the forum of science, and numbered with the fables of antiquity.

Again, that the melancholic and phlegmatic temperaments are modifications of the same physical constitution, would appear from the fact, that they are both described as characterized by a narrow chest, a deficiency of animal heat, a feeble circulation, an impoverished state of the blood, a

pallid or livid complexion, and langour of all the functions: but with this difference, that the former is marked by a higher development of the nervous system, with a greater tendency to intellectual exertion, which leads to exhaustion, and predisposes to indigestion, torpor of the bowels, lowness of spirits, insanity, apoplexy, paralysis, and other forms of nervous disease,—whereas the phlegmatic constitution is generally marked by a predominance of the abdominal viscera over the brain, an inanimate expression of countenance, a soft and flaccid state of the muscles, with a tendency to dropsy, diabetes, scrofula, and other diseases which arise from debility.

That Lord Bacon regarded the choleric as identical with the sanguine, and the melancholy with the phlegmatic temperament, would appear from his remark, that the humours of a young man are choleric, and his blood inclined to heat,—in an old man, phlegmatic or melancholic. (Life and Death.) With many other modern physiologists, Dr. Cullen maintains that the sanguine and phlegmatic temperaments are characterized by light, sandy, yellow, or brown hair, and fair skin; while some maintain that the choleric and melancholic are marked by dark, coarse, and curly hair, with a yellowish or brown complexion. But if we except the pale, sallow, and livid hues, that result from an impoverished condition of the blood, complexion has very little more con-

nexion with temperament than the colour of our garments; for when it is yellow, olive, brown, or black, and the cuticle thick, the richest blood does not shew itself in the skin; but when fair, the cuticle thin and transparent, it shews its character in the florid, pale, or livid hue of the face. The opinion of the ancients that yellow and dark complexions depend on the excess of yellow or black bile, was adopted by Blumenbach and Smith, who imagined that the blackness of the negro race is owing to an excess of the hepatic secretion in hot climates; whereas complexion is only skin deep, but temperament involves the whole physical and intellectual organization.

The division of temperaments into sanguine, choleric, melancholic, and phlegmatic, has remained from the time of Hippocrates down to that of Dr. Gregory, who added a fifth division, which he denominated the nervous. But another classification has been recently proposed and ably supported by Dr. F. Thomas, in a Treatise entitled *Physiologie du Temperamens*, published at Paris in 1826; in which the intelligent author refers all the varieties of constitution to the relative size of the thorax, brain, and abdomen. He maintains that when the lungs are more highly developed than any of the other principal organs, the temperament is *thoracic*,—that when the brain is large, compared with the chest and abdomen,

it is *encephalic*,—and that when the abdominal viscera are highly developed, compared with the thorax and brain, the temperament is *abdominal*.

The essential parts of this theory have been adopted by Dr. Caldwell, of Kentucky, and ingeniously carried out, in a recent work on Malaria and Temperament. With a strong prejudice against the humoral doctrine,* and a singular partiality for the hypothesis of Cullen, he maintains, that as " the solids are the ruling portion

* Dr. Caldwell maintains, that " *humoralism* is one of the most fearful and destructive monuments of error that has ever been erected,—an idol, which, through the many centuries of its existence, has done nothing but falsify and adulterate the principles, and lamentably pervert the practice of medicine,—that physicians have sacrificed millions of their fellow beings under the fatal spell of its influence,"—that *although the fluids may be vitiated in their condition, disease is not predicable of them, according to any legitimate interpretation of the word.* But the only reason he deigns to assign for these remarkable assertions is, that " we know nothing of the manner in which the blood is affected by different kinds of food and drink, medicines, and morbid states of the atmosphere,—nor what condition of the blood predisposes to disease, and what affords security against it." (On Malaria and Temperament, pp. 124. 208. 212. 217.) Now, with due deference to the opinions of my old friend and medical instructor, it does appear to me, that millions of our fellow beings have been sacrificed, owing to the *ignorance of physicians in regard to the true theory of sanguification, secretion, nutrition, and the manner in which the vital properties of the blood are impaired*,—and that it is high time they should set about ascertaining how it is affected by food and drink, various states of the atmosphere, medicines, passions of the mind, vicissitudes of temperature, &c.

of all organized matter, they must be looked to *exclusively* as the ground of temperament,—that it depends, first, on diversity in the minute interior or radical structure of the tissues which compose the body,—and, secondly, on difference of size and vigour in certain ruling organs of the system,"—by which he means the thorax, brain, and abdomen.

But neither of these distinguished physiologists has even attempted to explain in what the diversity of organization and radical structure of the tissues consists; nor why it is, that among different nations, certain ruling organs are more fully developed than among others. The principal advantage of their new classification is, that it is simple, and appeals more directly to the senses, than that of the ancients. At the same time, it must be confessed, that, in other respects, it is imperfect and erroneous. In the first place, the thoracic temperament of Thomas and Caldwell does not differ essentially from the sanguine; for they both represent it as marked by a high temperature, great activity of all the vital functions, and a full development of the muscular system, as in the Grecian statue of Hercules, and in all athletic individuals. But they have overlooked the fact, that among the natives of cold climates the chest is larger in proportion to the whole body than among the nations of the middle lati-

tudes, or any other parts of the world, while it is well known that the polar inhabitants are diminutive in stature, and of a *feeble* or *phlegmatic constitution.* It is therefore clear, that a comparatively large chest is not always an indication of activity and great muscular power.

Nor is it true, as they maintain, that a large thorax is generally accompanied with a small brain or one of moderate size; for Plato had a large head; and it is said that he took his name from the great breadth of his chest. Dr. Caldwell also informs us, from personal observation, that General Washington had a large head; and it is notorious that he had a remarkably broad chest, Herculean frame, and corresponding muscular power. The celebrated Mirabeau, like Daniel O'Connell, was equally distinguished for the enormous size of his head, and for the capacity of his thorax. Nor is it true, as a general rule, that a large abdomen is an indication of the phlegmatic temperament, as maintained by Thomas and Caldwell: for in Mirabeau, O'Connell, and hundreds of others that might be mentioned, it would be difficult to say whether the thoracic, the encephalic, or the abdominal organs predominate. How, then, shall we determine to which temperament they belong?

Another objection to the above classification is, that it does not embrace many individuals of

the choleric, melancholic, and phlegmatic temperaments of the older physiologists.* It is true, that, in one respect, the encephalic corresponds with the choleric constitution ; for they are both represented as characterized by great energy of passion, sentiment, and intellect. But it is not true, as maintained by Thomas and Caldwell, that the encephalic temperament is generally distinguished by a small or moderately sized chest, and want of energy in the vital functions. There are also many individuals who answer to the melancholy and phlegmatic temperaments, in whom all the principal or ruling organs are imperfectly and yet so equally developed, that they cannot be said to belong either to the encephalic or abdominal divisions. It is therefore manifest, that Thomas's classification does not embrace all the diversities of constitution ; and that there is still room for one that is more simple and comprehensive. Moreover, if it be a fact that all the organs are formed immediately from, and vitalized by, the blood, it is manifestly an

* Nor does it explain the manner in which temperament is modified by age ; for it is certain that nearly all persons in vigorous health, during youth and the meridian of life, are sanguine and vigorous,—that men are more so than women,—but that during old age they become weak and phlegmatic or melancholic, even when the thorax is large, especially among such as have been intemperate, or who have over exerted their intellectual faculties, and spent the summer of their life in excesses of any kind.

error to overlook the influence of the fluids on the development of the solids.

Again; if it be true, as I have endeavoured to demonstrate in a preceding chapter, that animal heat is the agent by which blood is formed and converted into the different tissues; it must determine the radical structure, relative size, and power of all the organs, fashion every part of the body, and regulate every variety of constitution or temperament,—whether we regard it as depending on the condition of the fluids, as maintained by the ancients; or on the relative size and vigour of certain ruling organs, as maintained by Thomas and Caldwell. It also follows, that as the quantity of organic particles in the blood, and the aggregate vital energy of animals, are in proportion to the capacity of their lungs and the amount of their respiration; all individuals with a broad, deep, and full chest, belong to the sanguine, or what I propose to call the *dynamic temperament*, whether the brain and abdomen be large or small, and whatever the complexion may be:—but that all persons, with a narrow, flat, or small chest, in whom respiration, sanguification, and nutrition, are imperfectly performed, have feeble constitutions, and belong therefore to what may be called the *adynamic temperament*, which includes the melancholic and phlegmatic of the ancients.*

* Should physiologists not approve of this classification, as not sufficiently descriptive, they may have a choice of the following,

In accordance with the Grecian axiom, that "strength is derived from spirit and from blood," and depends on the amount of caloric that passes through the body in a given time; it may be observed that birds belong more emphatically to the sanguine or dynamic temperament than mammalia, and the more active among the latter, than such as have imperfect organs of respiration, and therefore fall into a state of lethargy during winter; but that all warm blooded animals in perfect health are of a sanguine constitution, and belong to the dynamic temperament, when compared with reptiles and fishes, which are cold blooded, imperfectly organized, deficient in strength, and therefore belong to the adynamic temperament, which includes all individuals of the human species, with small chest and diseased lungs, whether cold and dry, or cold and moist.

According to the analyses of Denis and Le Canu, the average proportion of solid particles in the blood of vigorous and healthy men during youth, adolescence, and middle life, varies from

until something both accurate and more definite is offered. For example, when the thorax is large, the brain finely developed and well formed, the temperament may be denominated *sanguineo-cerebral*,—when the thorax and muscles predominate, it may be called *athletic*, or *sanguineo-muscular*,—and *sanguineo-abdominal* when the chest and chylopoietic organs are large. But if the brain be large, the chest small, or the lungs imperfect, the temperament may be regarded as *nervous*: or if the thorax, brain, and muscles be small, and the abdomen predominate, it may be termed *phlegmatic*.

12·92 to 15·85 per cent; whereas in persons of feeble constitution, they varied from 11 to 8 per cent. They also found that in persons labouring under phthisis, scrofula, scurvy, rickets, dropsy, and other low diseases, the ratio of solid particles varied from 8 to 6·40 per cent. or nearly the same as in cold-blooded animals, in which the solid matter varies from 8 to 4·80; corresponding with the imperfect developement of their lungs, brain, muscles, and whole organization. Hence a common expression among the vulgar, in regard to persons whose blood is impoverished, that they are "weak as water."

The dynamic temperament embraces the sanguine and choleric of Richerand, the thoracic of Thomas and Caldwell, with some other subordinate varieties. For example, if the chest be large, the lungs sound, the body not encumbered with fat, the health good, the muscles fully developed, and the brain small, we have what has been called the *athletic* temperament, as in boxers, wrestlers, agricultural labourers, and other individuals who have spent their lives in active employment of the muscles. In professional boxers, stone masons, and blacksmiths, the muscles of the chest and arms, are the most fully developed; whereas among porters, pedestrians, and savage tribes, those of the lower extremities predominate, because more constantly exercised. In the middle latitudes of Europe, the mean

circumference of the thorax, or that of the average man, does not exceed 36 inches; while in men of the largest size, it varies from 48 to 52, and even 58 inches; according to the best information I have been able to derive from respectable London tailors.*

But if the thorax be broad, round, and full; the waist small, the muscles moderately developed, the brain large and well formed, we have what may be called the intellectual temperament, which corresponds with the choleric of the ancients, and comprehends the noblest specimens of the human race. It is finely portrayed in the following soliloquy of Hamlet:—"What a piece of work is man! how noble in reason! how infinite in faculties! in form and moving how express and admirable! in action how like an angel! in apprehension how like a god!" The greatest

* It is much to be regretted, that so little attention has been given by ancient and modern writers on the natural history of man, to the size and configuration of the thorax among nations and individuals, with a view of ascertaining how far they are modified by climate aud modes of living. For it is of much greater importance to know the character of the chest and head, than the stature of mankind; which, however, should not be omitted in our attempts to ascertain the best methods of improving the physical, intellectual, and moral character of the race. But it is worthy of notice, that the circumference of the thorax is not always an exact measure of the size of the lungs; for it is deeper or longer in some persons than in others. The form most favourable to strength, is that of fulness in front and behind, with a corresponding depth, as in men of round backs.

poets, philosophers, orators, statesmen, inventors of arts, and heroes of the world, have been formed after this beautiful and classical model, so far as we can judge from portraits, busts, and the imperfect descriptions of historians and biographers. Such was the physical character of Democritus, Hippocrates, Pericles, Socrates, Plato, Zeno, Alcibiades, Alexander, Julius Cæsar, Brutus, Cassius, Cicero, Seneca, and Virgil, among the ancients,—and of Galileo, Bacon, Shakspeare, Luther, Melancthon, Petrarch, Tasso, Sully, Richlieu, Cromwell, Milton, Newton, Franklin, Washington, Mirabeau, Burns, Watt, Napoleon, Wellington, and Byron, with many other modern heroes, sages, and benefactors of mankind.

The truth is, that General Washington, the Duke of Wellington, and many other illustrious men, have been even more remarkable for the capacity of their chests, and for the absence of all superfluous fat, than for the magnitude of their heads. The same observation applies to Napoleon when young:—for although he had a fine classical head, with a large forehead, it was less massive than that of either Bacon or Franklin. And if we can depend on the cast of him taken by Dr. Antomarchi, soon after his death, his head was very little above the average size among intellectual men; while in all the portraits of him he is represented with a deep, round, and full chest. Nor is the head of Lord Brougham much,

if anything, above the average size. But as it is supported by a long and large thorax, compared with the size of his spare body, he is endowed with extraordinary mental activity, and the power of long continued application,—and a spasmodic quickness of movement, which marks an excitable state of the nervous system.

Again, if the chylopoietic viscera be more highly developed than the brain, we have what Thomas calls the "abdominal temperament," which embraces that very large class of persons described by Shakspeare, with "fat ribs and lean pates." Even when the thorax is large, the head of moderate size, and the body supplied with an abundance of rich arterial blood, a large proportion of it is expended in the secretion of fat, which is deposited in the cellular tissue, where it hangs as a burden on the system. But here again, it is worthy of notice, that the accumulation of fat indicates imperfect sanguification, owing to excessive alimentation, want of exercise, or some defect in the function of respiration. And that this state is not natural, but acquired by over indulgence, or the want of suitable exercise, would appear from the fact, that many of the lower animals when domesticated, highly fed, and prevented from taking exercise, become very fat, and much less active than in the wild state. Men of the above class are generally good natured and contented, while they have plenty to eat and

drink; but they love repose, and dislike profound thinking, or indeed any kind of exertion. It is true, that Dr. Johnson, Gibbon the historian, and some other highly intellectual men, have been fat and large around the waist. But I am not aware that any great hero or genius of the first magnitude, has been remarkable for obesity. Compared with such men, Julius Cæsar, the spare Cassius, General Washington, the Duke of Wellington, and Lord Brougham, are what the large chested and fine blooded racer is to the heavy and unwieldy dray horse. For the same reason, men of moderate stature are stronger and more active in body and mind, than such as are above the middle size. Thus we perceive, that all individuals with a large thorax and sound lungs, belong to the strong or *dynamic temperament*, of which there are several varieties; such as the muscular or athletic, the intellectual or cerebral, and the abdominal,—which are often so combined as to form other subordinate varieties of a mixed character.

On the other hand, whenever the thorax is below the ordinary size, or the function of respiration is imperfect, there is a deficiency of animal heat, and of rich arterial blood, with a languid state of all the vital forces; constituting the weak or *adynamic temperament*, whether the muscles, brain, or abdominal organs predominate. But if the nervous system be considerably more deve-

loped than any of the other tissues, we have that variety termed by the ancients the melancholic, which corresponds with the *nervous* temperament of Richerand and other modern Physiologists. For they are both represented as marked by a small chest, a pale, sallow, or livid complexion, (indicating a deficiency of bright arterial blood,) a languid circulation, torpor of the stomach, bowels, and of all the secretions, a spare habit, small, soft and feeble muscles, morbid sensibility, sudden fluctuations of temper, with a predisposition to nervous and spasmodic affections. And we have already seen, that the principal difference between this temperament and the phlegmatic is, that in the latter, the abdominal organs are more highly developed than the brain, which is weak and lethargic.

It is therefore evident that the adynamic temperament, whether cold or dry, or cold and moist, —whether denominated melancholic, nervous, or phlegmatic, and whether hereditary or acquired, is rather the effect of disease than a primitive or natural constitution. And that it is often acquired, would appear from the well known fact, that many distinguished individuals who were originally of the sanguine temperament, have been rendered melancholic or nervous by grief, anxiety, intense study, a sedentary life, and repeated shocks of adversity ; as exemplified in the characters Dante, Petrarch, Tasso, Pascal,

Cromwell, Newton, Voltaire, Rousseau, Zimmerman, Collins, Cowper, Burns, and Byron. The misery of such men is owing to a greater activity of the nervous system, than it has the physical power of supporting,—or as Thomas Carlyle observes, it is "a consequence of their greatness," and the intensity of their desire to get "a deeper insight into the heart of things." (Hero Worship.)

That the intellectual powers of man are in proportion to the magnitude of his brain, *ceteris paribus*, especially its frontal portions, would appear obvious from the corresponding gradations of intelligence among nations, as we ascend from the African, the Cairib, the Esquimaux, and Samoiede, of the artic regions, the North American Indian, the Malay, the Mongolian, the Hindoo and Arab, up to the European, who has the largest forehead, and the finest intellect of them all. Nor is it less certain, that among the lower animals, intelligence corresponds with the size of the brain, and the fulness of its anterior portions, as in many of the smaller birds, the better educated dogs, the horse, elephant, and the higher orders of the monkey tribe, in which the form of the head, and the degrees of intelligence, are exceeded only by man.

The sensibility of any organ is also in proportion to the abundance of nervous matter with which it is supplied, *ceteris paribus*. For example, in the eagle, hawk, and many other birds, the

power of vision corresponds with the enormous size of the optic nerves and tubercles. The sense of smelling is likewise more acute in the common hound in which the olfactory nerves are spread over an extensive surface, than in other dogs; while in the grey-hound, whose nose is small, the sense of smell is very imperfect. The mouth and nose are larger in the African, the North American Indian, and some other savages, than among civilized nations, who are inferior to them in the faculties of taste and smell. Dr. Caldwell says, that the sensuality of men is indicated by the size of the mouth, lips, nose, and reproductive organs.

But *why is it that many individuals with moderately sized heads, possess far greater power and activity of mind than others who have large and well formed heads?* Until this problem is solved, human physiology, and especially that important branch of it termed phrenology, cannot be regarded as a complete science,—even were it established that all the different organs of the brain, and their specific functions, had been fully discovered, which cannot yet be fairly assumed. In reply to the above, I have already shewn it to be a law of nature, that *the power of any organ is in proportion to the amount of rich arterial blood with which it is supplied, the quantity of caloric that passes through it in a given time, ceteris paribus, and depends on the amount of respiration.*

For example, the cohesive and contractile

power of the muscular tissue are much greater in birds than in mammalia, and greater in the latter than in reptiles or fishes, because birds are more rapidly nourished. For the same reason, the structure of the human brain is firm, dense, and powerful, in proportion to the rapidity with which its composition and vitality are renewed by the formative process. Hence it is, that by far the greater number of illustrious men have been distinguished no less by the capacity of the thorax than for the size and configuration of the brain. But if the chest be small, the lungs unsound, or if respiration be diminished by impure air, improper diet, intemperance, the depressing emotions, intense thinking, and a sedentary life, the vital properties of the blood are impaired, and the brain imperfectly nourished; so that although large and well formed, its texture is infirm or softened, and its power proportionally diminished. If the skull be thick, (as in the African,) or if the carotid and vertebral arteries are small, the brain will receive proportionally less arterial blood in a given time than when they are large; and still less when the chest is small, or the lungs imperfect. All persons of this class belong to the adynamic temperament, whether the brain be large or small. And owing to the softness of its texture, the capillaries are easily ruptured, giving rise to the effusion of blood or serum, apoplexy, paralysis, or idiotism. It is therefore

manifest, that this is not the temperament of robust health, nor of intellectual power to the highest extent.

It is a great blessing to be born with a large thorax; for it offers the surest pledge of vigorous health and long life. Had all men such chests as the Duke of Wellington or Daniel O'Connell, disease would be greatly diminished, and the duration of life augmented. I am informed that six individuals of the Wellesley family, recently alive, had arrived at the aggregate age of 443 years, making the average of each 74 years. And Mr. O'Connell stated, in a speech last year, that among 22 children of his grandmother, 11 arrived at the age of 96 or upwards. (Vide Examiner, March 14, 1841.) Like the heroes of Greece and Rome, the physical energies of these illustrious Irishmen were developed by exercise in the open air, and its free circulation through their capacious lungs, without which they never could have endured so much bodily and mental exertion.

With a full chest and sound lungs, men are able to endure degrees of cold, muscular exercise, loss of sleep, excesses in eating and drinking, that would soon shorten the lives of ordinary individuals. Nor is it true, as maintained by Thomas and other physiologists, that the thoracic or sanguineous temperament is peculiarly liable to inflammatory diseases. And there is reason to

believe, that a proper system of physical education would, in nearly all cases, prevent that imperfection of the thoracic organs which lays the foundation of phthisis, asthma, scrofula, and many other diseases which become hereditary, and embitter while they shorten life. The great secret of such an education is to give full scope to the instinctive love of exercise in the open air, so natural to children and all young animals. Is the chest narrow or flat in infancy? It may be greatly expanded and improved by frequent singing, reading aloud, dancing, playing at shuttlecock, the graces, and other agreeable pastimes, —or when there is sufficient strength, by fencing and other manly exercises. Are the superior and frontal portions of the brain imperfectly developed, compared with the lateral and posterior divisions? The former may be greatly improved by moderate exercise of the intellectual and moral faculties, for the same reason that the magnitude and power of any organ are augmented by action. And if the whole brain be unduly developed in early life, it should be exercised less than the lungs and muscles.

Thus it is manifest that, to a very great extent, we can modify these unbalanced conditions of the body which predispose to disease, immorality, crime, and suffering. But mankind have been so long in the habit of violating the laws of health, by intemperance in diet, the use of intoxicating

liquors, poisonous drugs, too much or too little exercise, undue indulgence of the passions, unnecessary exposure to vicissitudes of temperature and bad air, that a beautiful organization and sound health are confined to a very small number, even in temperate climates, where they should be almost universal. The human mind has also been so filled with falsehoods and pernicious prejudices, from infancy up to maturity, that its native clearness in the perception of truth is greatly dimmed, and the kindling power of genius is still more rare. Nor is it to be expected that men should fully obey the laws of nature and of the animal economy, until they shall be more thoroughly understood. A correct knowledge of the mean size of the thorax and brain in infancy, in both sexes, would enable us to regulate the employment of different individuals, so as to create the most perfect physical, intellectual, and moral organization.

In regard to the influence of climate on temperament, it is maintained by Dr. Prichard, that the African negro exceeds all other races in the *firmness and density of his fabric.* (Nat. Hist. of Man, p. 172, 1st Edit.) What is still more remarkable, it is maintained by Menzel, that *the choleric temperament prevails in the north, the sanguine in the south, the melancholy in the east, and the phlegmatic in the west:*—that the *will* predominates in the first, *sense* in the second, *feeling* in the third, and

understanding in the fourth:—finally, that men belong to the choleric and phlegmatic temperaments, in which the will and the understanding predominate; but women to the sanguine and melancholic, in which sense and feeling predominate. (German Literature, vol. ii. p. 102.) But the thorax, brain, muscles, and all the more important organs, are more highly developed in temperate climates than in either the tropical or polar latitudes,—because respiration, sanguification, secretion, nutrition, and all the forces of life, are diminished by a high temperature; and because, in excessively cold climates, animal heat is more rapidly abstracted by the surrounding atmosphere than it is obtained by respiration. From which it is obvious that the sanguine or dynamic temperament, with all its complications, whether athletic or intellectual, belongs emphatically to the middle latitudes; while in the tropical and polar regions, the adynamic constitution, with all its various modifications, predominates.

The higher development of all the organs in temperate climates, leads to a proportionally greater exercise of them, by which their development and power are still further augmented. So far is it from being true, as suggested by Menzel, that the sanguine temperament prevails in the south, and the phlegmatic in Europe, that the very reverse is the fact. And we have seen

that there is no foundation in nature for the existence of a choleric temperament, unless it be regarded as a modification of the sanguine with a large brain; and that the melancholic is a modification of the phlegmatic, with a predominance of the brain over the other organs, as in Dante, Petrarch, Tasso, Zimmerman, Cowper, Collins, and some others; in whom it was probably induced by over exertion of the nervous system, aided by an undue development of cautiousness and the absence of hope.

As for the rest, the cerebral or intellectual temperament is more common in cities and large towns than in the country—among scientific, literary, and professional men, including artists and the higher mechanics, than among servants, day labourers, small farmers, common mechanics, soldiers, seamen, boxers, and wrestlers, in whom the thorax and muscular organs are more fully developed than the brain, because more exercised, as proved by phrenological measurements.

Theory of Spasmodic Diseases.

It was said by a writer in Blackwood's Magazine, that the discovery of a remedy for hydrophobia would be worthy of a great national reward, or even a title of nobility.* But are we not

* Alas! such is the present standard of morality, even among the most civilized nations, that the man who should invent some

equally in the dark in regard to the nature and treatment of tetanus and all other spasmodic diseases? Has any one explained their proximate cause, or laid down any certain principles of treatment which apply to all cases? Besides, the number of deaths from hydrophobia was only 15 throughout England and Wales, and 124 from tetanus, in the year 1839, according to the Registrar General; whereas it was 25,408 from all other spasmodic maladies.

It was observed by Dr. Cullen, that "as we know not the condition of the brain in the ordinary conditions of the will, we are also ignorant of its preternatural state in all involuntary movements." And Mr. Morgan says, in a Lecture on Tetanus, published in 1833, that "we can take no credit to ourselves for curing a disease, respecting the proper treatment of which we positively know nothing." In accordance with the theory of Boerhaave, that "convulsions are owing to a vigorous influx of nervous influence into the muscles," Bichat referred them to a "preternatural activity of the cerebral functions."* Others

dreadful engine of destruction, or perpetrate some thousand murders on the field of battle, would stand a much better chance of receiving a great national reward, than if he were to discover an exact method of saving millions of human beings from disease and premature death.

* Some late writers erroneously maintain that strychnia, brucia, nux vomica, the upas ticuti, and other narcotic poisons, *augment the irritability of the muscular fibres ;* therefore should be given

maintain, with Dr. Billing, that their primary seat is in the white medullary portion of the brain; and others, with Dr. M. Hall, that they originate in the spinal marrow; while Liebig refers them to "an unequal degree of conducting power in the nerves."

But that they are owing, in nearly all cases, to diminished vitality of the brain, will appear from the following facts:

1. *That, in all the higher orders of animals, convulsions are invariably produced by a great and sudden loss of blood, as when they are bled to death.* And it is generally known, that they often follow excessive hemorrhage from the uterus after parturition. Why, then, is it that blood-letting is often practised in cases of tetanus, hydrophobia,*

in cases of paralysis; but that as conia and the ticunas diminish irritability, and produce paralysis, they should be given in tetanus and hydrophobia.

* With a candour and magnanimity worthy of commendation, Dr. Elliottson gives it as his opinion, that he hastened the death of a woman labouring under hydrophobia, by bleeding. Dr. Clutterbuck also employs it in the same disease. Yet he acknowledged before the Medical Society of London, a few years ago, that everything had hitherto failed. And it has been said that *all the Sampson remedies in the materia medica should be separately tried in succession.* Such is the glorious uncertainty of physic, that in the treatment of diseases, the most opposite remedies are thrown into the stomach, "without rhyme or reason," so that when the patient recovers, it is impossible to know what one has produced the effect, or whether it was owing to the efforts of nature, in spite of a confused and empirical practice. For example, in the Medico-Chirurgical Transactions of 1815, there is

and other spasmodic diseases? Is it not more in accordance with reason and common sense to follow the maxim of Hippocrates, that diseases are to be treated by remedies of an opposite nature from that of the causes which produce them? (*Contraria medentur contrariis*). Or is it more philosophical to follow the homœopathic doctrine, that *Similia curantur similibus?*

2. *But convulsions are also produced by the sudden abstraction of animal heat from the body, without any loss of blood, or when its temperature is reduced several degrees below the natural standard, as shewn by the cramps induced by the exertion of swimming in cold water.* Yet the cold bath has been frequently employed as a remedy for tetanus. As might naturally be supposed, it has, in several cases, proved almost instantly fatal.

3. *It is well known that all the more active narcotic and other poisons, when taken into the stomach, or absorbed into the circulation, produce convulsions and death.* Yet we are informed by Samuel Cooper, in his First Lines of Surgery, that solu-

a case of tetanus, related by Dr. Phillips, brought on a young lady of delicate constitution by exhaustion from dancing and subsequent exposure to a cold atmosphere. In the first place, he had her put into the warm bath for fifteen minutes, when she became so much relieved that she begged not to be removed from it, and was allowed to remain fifteen minutes longer. In the mean time he bled her, when she seemed greatly exhausted, and the spasms returned, with faintness and vomiting. Yet he prescribed calomel and scamony, epsom salts and senna.

tions of opium, arsenic, and even hydrocyanic acid, have been injected into the veins, with the view of curing hydrophobia. In his Lectures on the Blood, Magendie states, that by injecting simple water or the serum of blood into the veins of dogs, he produced difficult breathing, stupor, apoplexy of the lungs, a dissolved condition of the blood, convulsions, and death ; yet he informs us that he treated a case of hydrophobia by injecting two *litres* of tepid water into the veins. (Lancet, December, 1838.) And he observes in another place, that " so great is our ignorance of those physiological derangements called diseases, that it would, perhaps, be better to do nothing, and resign the complaints we are called on to treat to the resources of nature, than to act as we are frequently compelled to do, without knowing the *why* and *wherefore* of our conduct, and at the obvious risk of hastening the end of the patient." I would add, that when the attainment of certain knowledge is possible, it is an act of criminal ignorance, next to manslaughter, to practise on the lives of our fellow beings, without knowing the why and wherefore of our conduct.

4. *When the temperature of the body is reduced several degrees below the natural standard, as during the cold stage of intermittent fever, there is a constricted state of the skin, chattering of the teeth, trembling of the limbs, and a spasmodic state of the whole system, as when exposed to a very cold*

bath. The pulsations of the heart are exceedingly weak, and the circulation through the lungs is so far diminished, that the blood loses its florid hue even in the arterial capillaries, as shewn by the livid hue of the skin. In malignant cholera, the inspirations have been so few as seven per minute, and the temperature of the blood from 10° to 25° below the normal standard, attended with a spasmodic state of the stomach, bowels, and abdominal muscles, including the flexors of the extremities. In short, whenever the temperature is reduced below the natural standard, whether by the abstraction of animal heat from the surface, or by diminished respiration, owing to the influence of an impure atmosphere, the vital properties of the blood are impaired, and a tendency to spasmodic action induced. Dr. Johnson tells us, that " men die of cholera in precisely the same way as from hemorrhage,—with shrinking, paleness, and coldness of all the external parts, *diminished circulation*, (the most universal and essential symptom of cholera,) and spasms. It is therefore evident that the proximate cause is a deficient supply of animal heat and of good arterial blood.

5. *Convulsions are produced by strangulation, as in hanging and drowning, or by whatever arrests or greatly diminishes the process of respiration, whether it be exposure to the mephitic gases, the rarefied atmosphere of high mountains, a blow on*

the head, or violent emotions of terror and other depressing passions. The spasmodic tremor of the hands caused by intemperance in the use of ardent spirits, mercury, opium, and other narcotic poisons, is owing to diminished respiration and a vitiated condition of the blood, like the subsultus tendinum of typhus and other malignant fevers, attended with a great loss of vitality and general prostration of strength.

When the vital energy of the brain is much exhausted, every sudden impression, whether by sight, hearing, or touch, causes the whole frame to start, and, in many cases, brings on repeated spasms, which, in persons of extremely shattered nerves, are induced by the shutting of a door, or by the slightest current of air. At the same time, it is equally manifest, that in cases of hydrophobia and traumatic tetanus, spasms are caused by the irritation of a wounded nerve, in the same way that pricking the nerve of a frog excites involuntary or spasmodic contraction of the muscles.

The convulsions of infants are far more prevalent, and require more prompt treatment, in hot climates than in the middle latitudes, and more so in the latter during summer, when the atmosphere is in a rarefied and impure state, than during winter, especially in large towns, and crowded or ill ventilated dwellings. But cold and moisture are by far the most general ex-

citing causes of *cholera infantium* and other spasmodic diseases; to which may be added, the process of teething, irritation from worms, and improper diet,—all of which tend to diminish the function of respiration, and to prevent the due arterialization of the blood, as shewn by the frequent coldness of the extremities, the pale or livid* hue of the features, loss of appetite, general debility, and derangement of all the secretions. In the convulsive fits of new born infants, the lungs should be inflated by blowing into the mouth of the patient, with the nostrils closed, and by compressing the thorax after each inflation, so as to imitate the natural process of breathing. In this way the colour of the face may be changed from purple to red, before the voluntary action of the lungs is restored.

The most frequent predisposing cause of hysteria is the influence of grief, anxiety, and other depressing passions, by which respiration is diminished, as shewn by the difficulty of breathing,

* In all such cases the violence of the spasms, and dangerous condition of the patient, are in proportion to the difficulty of respiration, and the purple hue of the features, which are anxious, emaciated, and shrunken. Nor is there any chance of saving life without restoring the free circulation of blood through the lungs,—which can generally be accomplished by an early and judicious employment of the warm bath, frictions, diffusible stimulants, and the application of dry heat, so as to maintain the temperature of the body at the natural standard. But if this point be exceeded, there is danger of exhaustion.

palpitation of the heart, coldness of the extremities, flatulence, nausea, constipation of the bowels, lowness of spirits, and in some cases a feeling of suffocation, attended with stupor, faintness, loss of sensibility, a spasmodic condition of the muscles about the throat, alternations of sobbing and laughter, and general convulsions of the whole body. That the disease is often brought on by exposure to cold and a stoppage of perspiration, is equally evident from the copious discharges of limpid urine between the paroxysms. Some pathologists have referred the above symptoms to a congested state of the uterus, and suppression of the menstrual secretion. But like all the other morbid phenomena, this last condition must be regarded as a concomitant effect of the same causes which diminish the process of respiration, and impair the vital properties of the blood. Nor is it possible that any spasmodic disease can exist as long as the brain and general system are supplied with an abundance of good arterial blood, which is the fountain of life and health to all parts of the body.

According to the best writers on the practice of medicine, epilepsy is brought on by loss of blood, the mephitic gases, intemperance in the use of ardent spirits, violent emotions of terror, or whatever tends to diminish the power of the brain. And that the immediate cause of the frightful spasms which characterize the fit is the

want of good arterial blood in the brain, is manifest from the purple or livid hue of the face, shewing that, even in the arteries, the blood is black; consequently, that respiration is nearly or quite suspended during the paroxysm.

In all cases, the more suddenly the brain is deprived of good arterial blood, and its power of commanding the movements of the muscles destroyed, the more violent is their spasmodic action. For it must be remembered, that as the brain receives about five times more blood in a given time than an equal weight of the body in general, its power is abolished sooner by whatever diminishes the chemical function of the lungs, and the force of the circulation, than that of the muscles, which continue to contract for some time after the power of the brain has ceased, independent of its guidance, and therefore in a spasmodic or involuntary manner. The brain of infants is also much larger, and receives more blood, in proportion to the size of their bodies, than adults,—which is the reason they are more liable to spasmodic affections.

For example, in cases of decapitation, the muscles contract with more or less violence until their vitality is extinguished, — which proves clearly that spasms are "not owing to a vigorous influx of nervous influence into them from the brain," as supposed by Boerhaave and other pathologists,—nor to "an increased activity of

the cerebral functions," as maintained by Bichat and his disciples. Nor is it less manifest, that, in cases of epilepsy, (or when the process of respiration is suspended by exposure to the mephitic gases,) the power of the brain is arrested, or nearly so, while the muscles continue to contract with great force. In like manner, when respiration is greatly diminished, as in cases of cholera, the blood is sufficiently vitalized to enable the muscles to contract, although not sufficiently so to enable the brain to command their movements,—which is also the case in hysteria, chorea, the convulsions of children, the spasmodic twitchings of typhus, and the mobility of nearly all individuals while in a low or very feeble state of health.

The predisposing causes of tetanus are exhaustion from over exertion, or whatever diminishes the general powers of life, such as the elevated temperature of tropical climates, where it is more frequent than in the middle latitudes, and more so in the latter during summer than winter. But all the best writers on pathology agree, that exposure to cold after exertion in the hot sun, is by far the most general cause of idiopathic tetanus. Perhaps the most simple form of the disease is that local affection termed a crick in the neck, which is always produced by cold, and ought therefore to be cured by cold, according to the homœopathic doctrine of *similia curantur similibus*.

It happens, however, in this, (as in many other cases,) that the most pleasant, safe, and speedy method of cure is to restore that which has been lost.

Mr. Morgan relates the case of a sailor who deserted from his ship in the Thames, swam ashore, continued in his wet clothes all night, and was attacked with tetanus next morning. He also states, what has been observed by many others, that "the first complaint of the patient is, that he has taken cold, and is suffering from sore throat." (Lecture on Tetanus, 1833.)

What is called traumatic tetanus has been caused by dislocations, compound fractures, a severe burn, painful surgical operations,* such as castration, amputation of the breast, a limb, and almost every description of local injury, from a simple incision to the most serious laceration of the soft parts. Mr. Morgan knew a case produced in a scholar by the blow of a schoolmaster's cane across the back of the neck,—and another by a stroke of the same instrument on the back of the hand. Baron Larrey also knew a case produced by the lodgment of a fish bone in the fauces. And Dr. Willan relates another case that arose from intense anxiety of mind. We

* Hippocrates relates the case of Scamander of Larissa, in whom tetanus was induced by a large incision, followed by the actual cautery, in a case of diseased hip joint. (Epidemics, Book v.)

further learn from the British and French army surgeons, that, among wounded soldiers, tetanus is rarely brought on without exposure to cold, fatigue, or the depressing passions. On the 9th of January, 1839, Dr. Bird related before the Westminster Medical Society, the case of a man who had chopped the nail of his thumb on one hand, and injured the adjoining finger, but remained well for three days, when he was exposed to cold and wet, which produced a chill, followed by fever, and decided symptoms of tetanus. On the same occasion, Mr. Streeter related another case that was produced by cold alone; and which, like that of Dr. Bird, was cured by the ordinary treatment employed in fever. (Lancet, 1839.)

But whether the disease be idiopathic or traumatic, and whatever the remote or exciting cause may be, the prominent symptoms are essentially the same; viz. difficult and hurried respiration, cold extremities, a pale or livid hue of the surface, small and irregular pulse, loss of appetite, nausea, and sometimes vomiting, constipation of the bowels, with such a derangement of all the secretions, that the formation of pus is arrested in ulcerating wounds. Dr. Elliottson regards the disease as analogous to chorea, hysteria, and the shaking palsy. He also observes, that in ninety-nine cases out of a hundred, tetanus in females is attended with flatulency, globus hystericus, and other like symptoms.

But the most important general fact connected with the pathology of tetanus is, that in all the most malignant cases, the circulation through the lungs and general system is almost wholly arrested. As an example of this, it is stated in Cooper's First Lines of Surgery, that when Mr. Liston amputated the arm of a patient, with a view of stopping the progress of tetanus, brought on by a wound in the thumb, scarcely any blood flowed from the divided arteries, and no ligatures were required to prevent hemorrhage. Corresponding with this remarkable fact, we are informed by Cullen, and many other distinguished writers on pathology, that during the latter stages of the disease, the blood is so far dissolved as not to coagulate when drawn from the body,—in which it closely resembles the blood of patients labouring under malignant cholera, which is, emphatically a spasmodic disease.

In the worst forms of tetanus, the generation of animal heat by respiration is so far diminished, that the temperature of the body is below the natural standard; and the excitability is so far reduced, that enormous quantities of brandy and other diffusible stimulants have been often given without producing intoxication, or any perceptible increase of circulation. The system is in a condition resembling the nearly suspended animation from cold, during which the mephitic gases and narcotic poisons produce little or no influence.

For it has been observed, that during the advanced stages of tetanus, the most active purgatives rarely move the bowels; and that from thirty to sixty grains of opium have been given every six hours, without producing any visible effect. Mr. Abernethy relates the case of a man who died of the disease, in whose stomach were found thirty drachms of opium, which had not undergone any material change.

From all the foregoing facts and observations it is evident, that *the proximate cause of tetanus, as in spasmodic cholera, is a torpid condition of the circulation, a dissolved state of the blood, and a great loss of vitality*. Nor is it less certain, that if all the most powerful remedies in the Materia Medica were given in succession, they would be wholly unavailing, without restoring the vital properties of the blood, which can be done only by augmenting its circulation through the lungs, where it is formed and endowed with the power of carrying on all the functions. If the case be not too far advanced, this object can be attained by a judicious employment of the warm bath, the application of dry heat to the surface, inflation of the lungs with pure oxygen gas, or with the nitrous oxide, and the use of internal stimulants. In short, we must employ that agent by which the blood is perpetually formed in a state of health, enabled to excite the heart, and maintain all the functions in their natural state. But the

application of heat must not be continued after the body has been raised to the normal standard and the circulation restored, as it would then diminish respiration and defeat the object in view, which is to renovate the blood. When the circulation has been restored, respiration and the nutritive process may be augmented by sponging the body with cold water, and by the free admission of cold air,—which are so important in cases of syncope, and whenever there is fever. It is only, however, in the early stages and milder forms of the disease that tetanus is attended with fever,—because respiration is too much diminished to produce reaction. Yet Dr. Edwards relates a case on the authority of Dr. Prevost, in which the temperature rose to 110·6°.

In regard to hydrophobia, it is still a problem whether it is propagated by a specific and contagious virus, or whether it be a modification of tetanus, as supposed by Democritus and other ancients. Perhaps there is no subject on which the common sense of mankind has been more signally perverted by superstitious and groundless fears than that of hydrophobia, if we except the burning of poor old women for witchcraft. Within a recent period, Magendie says it was no uncommon thing to smother patients bitten by a rabid animal, between two feather beds, or to bleed them to death, with a view of speedily terminating their sufferings. And I have been told

that a case of the kind recently occurred in Scotland. The prevalent opinion of medical men, that it is a strictly contagious disease, was admirably ridiculed by Baron Munchausen, who gravely tells us that "his cloak became mad while in the wardrobe, after having been torn by a rabid dog." But to be serious, if hydrophobia be generated by a specific poison, it ought to be communicated in nearly all cases of inoculation with the saliva of a rabid animal, or by exposure to its bite. Yet we are informed by Mr. Youatt, that of five dogs which he inoculated with the saliva, not one became rabid. And he says, in another place, that he had never been able to produce rabies by inoculation with the saliva of a dead dog, nor with the blood of a living one in the rabid state.

It was long ago related by John Hunter, that out of twenty persons who had been bitten by the same mad dog, only one of them was attacked by the disease. And it was stated by Sir Benjamin Brodie, a few years since, before a Committee of the House of Commons, that out of above four thousand persons bitten by dogs suspected or actually rabid, since he had been connected with St. George's Hospital, not one, to his knowledge, had become hydrophobous. Now if canine madness were a contagious disease, like small pox, psora, lues, or gonorrhæa, is it possible that it should have failed in more than four thou-

sand cases? The story of Munchausen's cloak is scarcely more incredible. But Mr. Youatt thinks the contagious character of the disease has been proved by the experiments of Magendie and Breschet, who say they communicated it to a dog by inoculation with the saliva of a man who had hydrophobia. (See the Veterinarian, vol. iv. p. 225.) And Mr. Colman has proved that madness is often produced in dogs during hot weather, by confinement, exposure to their own breath, urine, and other excrements, improper food, and from too much or too little exercise. He does not, however, assert, that it is never communicated by inoculation. And he believes that typhus, jail fever, the itch, the farcy and glanders in horses, the roup in fowls, and the husk in pigs, are contagious maladies, often produced by impure air, filth, &c. without contagion. (Veterinarian, vol. iii. p. 636.)

Nor is there anything better established in the history of diseases, than that hydrophobia is often produced in the human species without contagion, or the bite of a rabid animal. And there is reason to believe that tetanus is often confounded with hydrophobia, if, indeed, they are not modifications of the same disease. Brodie relates a well authenticated case, published in the Philosophical Transactions above a century ago, of a man who died of hydrophobia a month after he was bitten by a dog that was alive and well two weeks before his death. Mr. Hutchinson also

related the case of Mrs. Sara Johnson, who had been struck on the nose by a little dog, but without causing the slightest abrasion of the skin; and who, about two weeks afterwards, (on the 20th of November,) got wet, when she was attacked with shivering, languor, depression of spirits, thirst, furred tongue, pain in the head, back, and limbs, difficulty of breathing, and agitation of manner. On the 23rd, the slightest motion of the air around her, or the sight, and even mention of fluids, induced hydrophobic spasms, and she died on the 24th, after expressing a belief from the first that she would not recover. Mr. Denby gave it as his opinion that the case was owing to fright and the influence of cold. (Lancet, 1839. Trans. of the Lond. Med. Society.)

A still more decided case of what is termed spontaneous hydrophobia occurred in my own practice, in the year 1827. A middle aged lady of phlegmatic constitution, took a long walk one afternoon in the month of August,—after which she sat down before an open window, exposed to a cool breeze, until she felt rather chilly. Soon after retiring to bed, a sensation of stiffness about the jaws came on. On visiting her the next day, I found there was an impossibility of swallowing, and the utmost horror on the approach of liquids to her lips,—owing to a spasmodic state of the muscles about the throat; which is the real cause of the dread of fluids;

but seldom occurs in the disease as it exists in dogs. The pulse was exceedingly small and feeble, the extremities cold, the complexion livid, and the features contracted, with an expression of extreme anxiety. Under these alarming circumstances, instead of arousing the nearly suspended circulation by the warm bath, or the application of dry heat, I vainly endeavoured to administer laudanum, brandy, and ether, which she could not swallow, and expired in convulsions the following day.

Nor can there be a doubt in the mind of any dispassionate medical practitioner, that in a large majority of cases in which hydrophobia follows the bite of a rabid animal, it is brought on by exposure to cold, fatigue, and the depressing passions. There are also many cases on record of its being produced in persons of timid and feeble constitutions by violent emotions of terror, without the bite of a rabid animal, or any local injury. The needless alarm of the community, arising chiefly from ignorance in regard to the cause of hydrophobia, is a thousand times worse than the disease, which must be treated like tetanus ; for the proximate cause is the same in both. And I venture to predict, that by an early employment of the means already suggested, they will both be found curable maladies.

In a small Treatise addressed to the French Academy of Sciences in 1823, by M. Bouisson, the author states, that nine days after attending

a woman who died of hydrophobia, he was attacked with a stiffness about the throat, a difficulty of swallowing fluids, and other symptoms of that frightful malady, which he supposed was brought on by wiping his hand (one finger of which had on it a slight sore,) with a towel that had been employed in removing saliva from the patient's mouth. Believing himself to be attacked with a mortal disease, he resolved on stifling himself in a vapour bath, which he had raised to 107°. But, to his great surprise and delight, he soon found himself relieved from all the previous symptoms, when he left the bathing room, dined heartily, and drank more wine than usual, without any return of the complaint.

Since that time, he says that he has treated above eighty individuals who had been bitten by dogs supposed to be rabid; in four of whom the symptoms of hydrophobia had clearly declared themselves: and that in no case had he failed, except in that of one child, which died in the bath. In addition to the repeated employment of the vapour bath, he recommends the practice of inducing free perspiration, by wrapping the patient in warm flannels, covering him well with blankets, or even a feather bed, and giving hot drinks; because he says, that hydrophobia is confined chiefly to animals which do not sweat, such as the dog, wolf, and fox. He further declares himself so confident in regard to the success of this

treatment, if adopted in the early stages of the disease, that he should have no objection to be inoculated with the saliva of a rabid animal.* Now although it must be admitted, that there is something romantic in the reason which Dr. Bouisson assigns for going into the vapour bath, and even a doubt whether his disease was not owing more to fright than to the influence of the woman's saliva, the practice he adopted was unquestionably rational; and when early adopted, is calculated to remove the proximate cause of nearly all spasmodic diseases, which I have shown to depend on torpor of the circulation, and a vitiated state of the blood, owing chiefly to a loss or deficient supply of animal heat.

* We frequently hear of individuals being attacked with hydrophobia several months, and even one or two years, after the bite of a dog supposed to be rabid. But as it is now admitted by some of the ablest veterinarians, that the latent period of the disease, when communicated by inoculation, never exceeds twelve weeks, it is probable that all the cases which occur at longer periods after the bite are owing to some other cause, as in spontaneous hydrophobia. For it is contrary to all analogy to suppose that a poison capable of producing such fatal effects, should remain latent for one or two years. The popular belief that individuals affected with this fearful malady bark like dogs, and even attempt to bite their attendants, must be referred to the influence of imagination and terror of the patient.

CHAPTER V.

Theory of Fever.

"I have always thought it a greater happiness to discover a certain method of curing the slightest disease, than to accumulate the largest fortune." SYDENHAM.

But how is it possible to arrive at a certain method of curing even the slightest disease, without knowing the cause of vital action during health, which consists in the natural and pleasurable exercise of all the functions? And if it be true, that "no genuine physiological principle has ever yet been discovered," how is it possible that pathologists should explain the phenomena of disease, which literally implies pain, or the absence of ease, and is always the result of some departure from the natural state of the functions? Such is the simplicity which pervades the infinitely diversified operations of nature, that a complete knowledge of any one disease would afford a key by which to unfold the rationale of all the rest.

For example, it may be laid down as an axiom, that *fever or inflammation, whether general or local, is an essential condition of all diseases, except in those cases in which the reaction is not sufficient*

to induce a preternatural temperature; as in syncope, apoplexy, the worst forms of cholera, cold plague, tetanus, hydrophobia, and other spasmodic affections. Yet the most enlightened authors of the present day admit, that the theory of fever is wholly unknown;* consequently, that the various methods of treating it are empirical, vacillating, inefficient, and often injurious.

It may also be received as a fundamental principle in pathology, that *every variety of constitutional disease is ushered in with a loss or deficient supply of animal heat.* But we are informed by Dr. Southwood Smith, in his work on Fever, that physiologists know so little about the mode in which animal heat is generated, that they have

* Dr. James Johnson observes, in his work on Tropical Climates, that the proximate cause of fever and other forms of disease is totally beyond our comprehension; and Dr. Alison regards it as "unreasonable to expect that we shall *ever* go far in explaining the peculiar phenomena of fever." (Outlines of Physiology and Pathology, p. 513.) He further observes, in another work, that "the adaptation of arterial blood to the maintenance of vital action in general and of circulation in particular, seems to be one of the primary laws or conditions of vitality, for which it is in vain to look for an explanation." (Cycl. of Pract. Med. Part xxiv.) Dr. George Gregory also observes, that "if we cannot unfold the nature of the healthy vital actions, it is not surprising that pathologists have failed in explaining those which occur in disease." (Theory and Practice of Physic, p. 164.) He seems fully aware that all the phenomena of disease are immediately connected with some derangement of the nutritive process. But he adds, "the whole subject of the functions of the capillary system is exceedingly obscure; and that Bichat considered it altogether beyond our reach."

given no satisfactory explanation of its diminution or increase during disease. In accordance with the views of Hoffman and Cullen,* he maintains that the chill and all the following symptoms are clearly referable to some derangement of the brain and spinal cord,—that the cold stage is produced by a disturbance of the respiratory and circulatory organs, which no longer receive their accustomed supply of influence from the nervous system; while the hot stage is owing to some morbid action of the pulmonary and systemic capillaries. (pp. 81-84. 345.)

* The celebrated theory of Cullen, as summed up by the author in his Practice of Physic, was, that " the remote causes of fever are certain sedative powers applied to the nervous system, which diminishing the energy of the brain, thereby produce debility in the whole of the functions, and particularly in the action of the extreme vessels:—but such, however, is, at the same time, the nature of the animal economy, that this debility proves an indirect stimulus to the sanguiferous system; whence, by the intervening cold stage, and spasm connected with it, the action of the heart and large arteries is increased, and continues so till it has had the effect of restoring the energy of the brain, of extending this energy to the extreme vessels, of restoring therefore their action, and thereby especially overcoming the spasm affecting them; upon the removing of which the excretion of sweat and other marks of relaxation of the excretories take place." But he never explained how the remote causes induce debility, spasm, and the cold stage; nor in what way the latter induces the hot stage. And what is still more difficult to comprehend, he represents both as efforts of the *vis medicatrix naturæ* to obviate the effects of morbific agents. (See Sections xlvi. lii.) But although Cullen speaks of his theory as " a generalization of facts, from a cautious and full induction," it is now very generally regarded as a mere tissue of gratuitous assumptions which explain nothing.

In a recent work on the Practice of Medicine, by Bright and Addison, the authors maintain that the primary seat of fever is the ganglionic system of nerves. Yet they observe, that " as we are ignorant of the nature and operation by which heat is evolved during health, we cannot offer any satisfactory explanation of the cause of its increase in fever and inflammation, unless indeed we may *suppose it to depend upon the more increased activity of the circulation*, which is manifestly present in the recent form of the disease." (p. 123.) And Dr. Tweedie repeats, " we know so little about the cause of the generation of animal heat, that no satisfactory explanation of its increase or diminution has been given." (Cyclop. of Pract. Medicine, Part viii. p. 158.)

But I have already proved in the foregoing chapters of this work, that all the remote or predisposing and exciting causes of disease tend to reduce the temperature of the body ;—that respiration is diminished by exposure to the high temperature of hot climates and seasons, impure air, imperfect nourishment, the depressing passions, intense study, intemperance in the use of spirits, narcotic and other poisons, loss of blood, or excessive evacuations of any kind, concussion of the brain, compound fractures, or whatever tends to lessen the voluntary command of the nervous system over the chemical function of the lungs, —that when the vital heat of the body is abstracted

by exposure to cold and moisture, or expended by muscular exertion, faster than it is obtained by respiration, the same general effect is produced.*

Pathologists have usually reduced the causes of disease to three classes, which they have termed the *remote*, *exciting*, and *proximate*. But the principal difference between the two first classes is, that the one precedes the other in the order of time; while the proximate cause is the result of their action, and implies that immediate condition of the body in which the disease consists, or what has been called *ipse morbus*. It has been often asserted by modern authors, that no one

* By far the most general exciting causes of fever, even in hot climates and malarious situations, is exposure to cold and moisture, after the body has been weakened by the predisposing causes. And it may be asserted with confidence, that in nineteen cases out of twenty, the chill might be prevented by due attention to warm clothing, aided by a light but nutritious diet, and by keeping up a fire at night to expel dampness. Grant Thorburn states, in his Auto-biography, that during the yellow fever in New York, he never saw a single case of the disease which was not brought on by exposure to rain, cold night air without sufficient clothing, fatigue, intemperance, or some other obvious and avoidable cause that was overlooked by the faculty, who seemed to regard only the vitiated state of the atmosphere. Many interesting cases which he relates in detail, and the judicious comments upon them, render his chapter on the subject highly important in a practical point of view. He says that whenever the epidemic made its appearance he put on his winter clothing; and that although constantly employed in attendance on the sick, he enjoyed uninterrupted health.

symptom is always present at the beginning of fever, and without which the disease could not exist. But so far is this from being true, that *there never was a general fever without a previous reduction of temperature, which is the first prominent link in the chain of morbid phenomena, and the invariable cause of all the following symptoms.* In accordance with this view, it was maintained by Hippocrates, that fever is uniformly ushered in with coldness or a loss of spirit, by which the humours are thickened and determined to the internal parts of the body.* (De Flatibus, sect. iv.—vii.) So far, his pathology was more clear than that of the moderns, who have repeated times without number, that "during the cold stage, from causes unknown to us, the blood leaves the surface, and becomes engorged in the viscera." But as Hippocrates knew not how animal heat is obtained by respiration, and transferred to the solids in combination with arterial

* However diversified the remote and exciting causes of disease may be, they all operate in the same way, modified, however, by their intensity or duration, and by the constitution of the patient. Some of them, as the narcotic and other poisons, not only diminish respiration, but disorganize the fibrin and red particles, or combine with and precipitate the albumen of the blood. That exposure to bad air also produces a morbid state of the blood long before the symptoms of disease are actually developed, would appear from some experiments of Dr. Potter, who found, during the prevalence of yellow fever in Baltimore, that the blood of individuals who lived in the infected parts of the city, (although from every outward appearance and inward feeling they were in per-

blood during health, it is not surprising that he should have given no explanation of the manner in which the various predisposing and exciting causes bring on the cold stage, nor how the latter produces the subsequent fever.

That respiration is diminished during the chill that ushers in the various forms of fever, pneumonia, bronchitis, influenza, and every other species of constitutional disease, would appear from some experiments of Jurine, who found that less carbonic acid was generated during the cold stage, and after blood letting, than during health. And it was found by Nysten that the same effect was produced by an obstructed or congested state of the lungs. The consequence of which is, that during the cold stage of ordinary fever, the temperature under the tongue is reduced from three to six degrees below the normal standard ; while in those malignant intermittents termed algid, it sometimes falls fifteen or twenty degrees below

fect health,) resembled that of persons labouring under the worst forms of the epidemic ; the serous portion on separating was of a yellowish or orange hue, and strikingly different from that of persons residing in the pure air of the country. He further states, that hundreds who escaped any formal attack of the fever, complained, at times, of nausea, giddiness, head-ache, constipation, general languor, with pains in the back and limbs,—shewing that the disease existed in a latent state, and required only some exciting cause, such as exposure to cold, fatigue, or intemperance, to bring it into full action. And it is notorious, that the inhabitants of malarious districts are generally pale or sallow, indicating an impoverished state of the blood.

the healthy average, as in the worst cases of epidemic cholera, in which respiration is so far diminished that reaction seldom takes place—unless by the timely employment of the warm bath, or the application of dry heat.

But as it is a law of nature that the force and frequency of the heart's action, *ceteris paribus*, are always in proportion to the temperature of the blood, they are diminished during the cold stage, as shewn by the slow and feeble or irregular state of the pulse; which is attended with shuddering and a spasmodic condition of the whole body. Moreover, as the blood is formed and renovated in the lungs by respiration, it follows that whenever this important function is diminished, the vital properties of the blood must be impaired, no less certainly than by the chemical influence of the narcotic and other poisons. For example, when the function of the lungs is wholly arrested, as in cases of drowning, hanging, or confinement in the mephitic gases, all the arterial blood in the body of a healthy man is changed to the venous state, and its power of carrying on the operations of life destroyed in about ninety seconds; the reason of which is, that it is no longer renovated by giving off carbon and hydrogen, nor by receiving its accustomed supply of vital heat. And as the temperature of the body is reduced below the natural standard, during the cold stage of fever, the blood is not

depurated, as in health, by the elimination of sweat, urine, and other excretions, which, being retained, must still further derange its vital properties. If at this stage of the disease blood be drawn from a vein, or even from the temporal artery, it is found to be unusually dark coloured, as might naturally be inferred from the livid hue of the surface, especially in cases of great depression, during which it is sometimes difficult to obtain a flow of blood, owing to its extreme viscidity.

If, then, it be true, that animal heat is the agent by which blood is formed, converted into the different organs, and maintains them in a state of healthy activity, it is evident that whatever tends to diminish the supply of this important principle must impair the healthy properties of the blood, and thus lay the foundation of disease. The essential symptoms are the same in every variety of fever, whether brought on by the abstraction of caloric from the influence of cold and moisture, its expenditure by over exertion, or by the various causes which diminish respiration. But as they are most distinctly marked in the intermittent form of the disease, I shall proceed to shew that all the morbid phenomena which characterize that type may be traced to a reduction of temperature, and a vitiated condition of the blood.

In the first place, that the shuddering or spas-

modic condition of the whole body, is not the proximate cause of ague, as maintained by Hoffman and Cullen, but a secondary effect arising from the loss or deficient supply of animal heat, is evident from the fact, that the same spasmodic condition is induced by immersion in the cold bath, and by exposure to the fumes of carbonic acid. Nor is it less certain, that the small and feeble pulse which marks the cold stage, is induced by whatever diminishes the temperature of the blood, the circulation of which through the lungs being impeded, causes anxious and difficult respiration. The surface is pallid or livid, because the blood is imperfectly arterialized; while the features are shrunken, and the extremities diminished in bulk, because they are not duly supplied with blood, which accumulates in the central organs. The bowels are torpid, perspiration is checked, and there is a deficiency of the urinary secretion, which is pale or colourless. And as the blood is no longer depurated by the excretion of those compounds that pass off through the emunctories during health, it becomes still further vitiated. For example, as about six pounds of matter are discharged every twenty-four hours from the lungs, skin, kidneys, and bowels, it is manifest that whenever this superfluous matter is retained for only a short time in the blood, its vital properties must be proportionally deranged. What then must be its condition

after all, or the greater part of the excretions have been locked up for several days, as in most cases of fever?

In the mean time, as the brain and nervous system are no longer supplied with good arterial blood, there is a loss of sensibility, impaired memory, confusion of thought, head-ache, and stupor, which, in some cases, approaches the condition of apoplexy. Again, that the loss of appetite, nausea, and sometimes vomiting, which attend the cold stage, are owing to a deficiency of good arterial blood in the capillaries of the stomach, is evident from the fact, that the very same symptoms are produced by excessive loss of blood, the influence of intense cold, the inhalation of mephitic gases, or the rarefied air of high mountains, emetics, the narcotic and other poisons, or whatever tends to debilitate that important organ, arrest the secretion of gastric juice, and with it the process of digestion. The consequence of which is, that no chyme is formed during the cold stage of fever to unite with bile, which accumulates in the gall bladder and duodenum, until discharged by vomiting, or in the form of bilious stools. It is therefore obvious that the proximate cause of fever is not an excess of bile, as maintained for the last two thousand years; nor debility of the brain and a spasmodic state of the extreme vessels, as supposed by Cullen; nor inflammation of the stomach and bowels, as sup-

posed by Broussais; but that the primary cause of these and all the other symptoms is a loss or deficient supply of the animating principle, and a consequent vitiated state of the blood, to which may be traced the universal debility of the brain, stomach, bowels, voluntary muscles, and the general feeling of soreness, with an aching in the back and limbs. Such are the cardinal symptoms that mark the cold stage of intermittents, which are invariably ushered in with diminished respiration, circulation, sanguification, secretion, nutrition, and of all the vital forces.

But as the process of breathing, although much impeded, is still carried on during the cold stage; and as very little of the heat thus obtained is employed in combining the blood with the solids, and in maintaining the various secretions, it gradually accumulates, until the temperature under the tongue rises to 104°, and sometimes to 107°, according to the observations of Currie, and some other pathologists.* The immediate

* According to the observations of Dr. A. Donné, recorded in the Archives Générales de Medicine for July 1835, the temperature and pulse in various diseases were as follows:—

	Temperature.	*Pulsations.*
Puerperal fever	102 to 104	152 to 166
Typhus fever	101·30 .. 104	84 .. 136
Inflammatory fever	96·40 .. 104	60 .. 102
Rheumatism	98·30 .. 101·75	76 .. 96
Enteritis	100·20 .. 101·58	76 .. 104
Phthisis	96 .. 103·10	68 .. 120

consequence of which is, that the action of the heart becomes more frequent and vigorous, by which the blood is propelled with increased force into all parts of the body, and the general torpor that existed during the cold stage is gradually removed.

Moreover, it is worthy of special notice, that as a larger amount of blood is sent through the lungs, more carbon and hydrogen are given off to unite with atmospheric oxygen; so that more caloric is obtained by respiration during the hot stage, and imparted to the blood, than even during health, as proved by the experiments of Jurine,

	Temperature.	*Pulsations.*
Pleurisy	94·38 .. 102·10	80 .. 106
Pneumonia	96·40 .. 103	92 .. 126
Hypertrophy of the heart	94·40 .. 103·10	64 .. 150
Chlorosis	99 .. 101·75	72 .. 104
Jaundice	96·40 .. 98·30	36 .. 62
Hemiplegia	99·72	124
Hysteria	98 .. 99·72	76 .. 102
Diabetes	96·40 .. 97·25	78 .. 84

But this table requires to be greatly extended, so as to embrace all the various forms of disease, during the cold and hot stages. In the Lancet of August 29, 1835, some experiments of Becquerel and Breschet are recorded, representing the temperature of patients labouring under various diseases at the *Hotel Dieu*, the results of which correspond with the above, as far so they go. In a scrofulous child during the febrile state, the thermometer in the mouth (it should always be under the tongue,) stood at 98·50^{o}; while in an inflamed tumour it rose to 104^{o}. They also found the temperature of a hemiplegic man 98·88^{o} on the diseased side, and 98·07^{o} on the sound side.

Nysten, and more recently by those of Mr. M'Grigor, who found that during the climax of scarlet fever, measles, and small-pox, from twenty to fifty per cent. more carbonic acid was exhaled from the lungs of patients in the Glasgow Infirmary than in a state of health. And it is a striking coincidence, that the pulsations of the heart are augmented in about the same ratio during the hot stage, the tendency of which is to improve the vital properties of the blood, by increasing the chemical function of the lungs in which it is formed and renovated, as shewn by the bright and florid hue which it assumes, the redness it imparts to the skin, and its increased power of coagulating when drawn from the body, compared with its dark, grumous, and vitiated state during the cold stage.

But as it is some time before the nutritive properties of the blood are restored, even after respiration is re-established, the caloric thus obtained is imperfectly transferred to the solids; so that there is often a feeling of chilliness while the patient feels preternaturally warm to another person, until the full development of the hot stage; attended with general debility, and a dull pain in the head, back, and limbs, not unlike that which is produced by the immediate influence of external cold; but with this difference, that in the former case it is more permanent and difficult to remove, because owing to a radical derangement in the vital properties of the blood.

The consequences of which are, that the secretions remain for some time suspended, as shewn by the clammy state of the mouth, furred tongue, dry skin, and thirst. The urine is also scanty and high coloured during the hot stage, but contains a larger amount of urea and other nitrogenous compounds than in a state of health, according to the experiments of Dr. Prout and other chemists. Yet it must be observed, that whatever amount of animal heat may be obtained by respiration, it is incapable of performing its healthy vital office until the blood is restored to its natural state. Nor is it more strange that a diminished transfer of heat from the blood to the solids should induce general debility, torpor of the stomach, bowels, and liver, pains in the head, back, and limbs, than that exposure to a March east wind, or sitting for some time in a cold room, should cause an aching, stiffness, and numbness of the extremities, or that a rapid expenditure of animal heat by over exertion should cause a general soreness and stiffness of the muscles.

But in ordinary cases of intermittent fever, the natural tendency of the hot stage is to limit its own duration, and put an end to the paroxysm. This it does by augmenting the action of the heart and the quantity of respiration, by which the vital properties of the blood are improved, and sent freely into all parts of the body ; when the

previous torpor of the brain, stomach, intestines, and voluntary muscles, is succeeded by an increased activity of all the functions. The effete matter of the system that had accumulated in, and still further vitiated the blood during the cold stage, together with the superfluous amount of caloric that marks the hot stage, are carried off through those natural sewers, the skin, kidneys, and bowels, when the sweating stage comes on, and puts an end to the paroxysm. Such are the leading symptoms that mark the progress of intermittent fever, which may be regarded as the type of all the other varieties.

But why do the paroxysms return at nearly regular periods of 24, 48, and 72 hours, as in the quotidian, tertian, and quartan forms of fever? Why is the cold stage longer, while the paroxysm is shorter, in the quartan than in the tertian, in which the cold stage is again longer, and the paroxysm shorter, than in the quotidian? Why is the chill shorter and less distinctly marked in fevers that continue, with slight remissions in the morning, for several days, or even weeks, than in intermittents? Why, in nearly all of them, should it come on more frequently in the early part of the day than after noon? And why, in continued fevers, does the remission occur in the morning? So far as I am aware, none of these important questions have ever yet been answered in a satisfactory and philosophical manner by pathologists.

The reason why the paroxysms of intermittent fever return at nearly regular intervals of time, must obviously be sought in those general laws of periodicity which mark the revolutions of the animal economy in health, under the influence of season, changes of temperature, day and night, sleeping and waking; all of which modify the various functions in a regular and uniform manner. This tendency to periodicity is strikingly exemplified in many of our artificial habits, which have been termed "second nature." For instance, if an individual accustom himself to remain awake until three o'clock in the morning for several weeks or months, and to rise at ten, it will be some time before he can go to sleep at an earlier hour, although he may rise at seven in the morning; and so of many other acquired habits, all of which, however, are subordinate to the revolutions of nature.

In accordance with the general theory of the ancients, that fever is owing to a redundancy of bile, it was maintained by Hippocrates, that the tertian, quotidian, and continued forms of the disease are determined by different quantities or degrees of vitiation of the biliary secretion; and that quartans are owing to an excess or viscid state of what he called black bile.* (Natura Hominis, v. vi. xxviii.)

* He further maintained, that fever is an effort of nature to expel morbific matter from the body by vomiting, purging, sweating, urine, spontaneous hemorrhage, cutaneous eruptions, tumours,

But it was contended by Cullen, that " the causes of the protraction of paroxysms, and therefore of the continued form of fevers, are, that the remote causes operate by occasioning either a *phlogistic diathesis, or a weaker reaction.*" (Practice of Physic, sect. lxv.) And he tells us, that " the phlogistic diathesis consists in an increased tone of the whole arterial system." From which it would follow, according to this theory, that the continued form of fever depends either on increased action, or diminished reaction. Besides, if the phlogistic diathesis mean any thing, it is merely a *feverish disposition,* and is the very thing which required explanation. In opposition

and abscesses ; or to render it harmless by a species of assimilation, termed by him concoction. And as the paroxysms of intermittent fever return at stated intervals, he supposed that a certain definite period is required to bring about what he called the crisis, whether favourable or not. But there is reason to believe, from his own statements, that it is only the milder forms of the disease in which the tendency of nature to observe stated periods can be distinctly traced ; and that even in these, they are often interrupted by mal-treatment, or by the operation of some violent exciting cause. For example, it was observed by that great man, that in 163 cases of fever, 107 terminated on one or other of the following days, the *third, fifth, seventh, ninth, eleventh, fourteenth, seventeenth,* and *twentieth,*—that none occurred on the second nor thirteenth, and by far the greatest number on the seventh, fourteenth, and twentieth,—that of the favourable terminations, less than a tenth happened on non critical days,—whereas above a third of those which were fatal occurred on the non critical days,—showing even in continued fevers, a tendency to periodicity, which, however, seems to be interrupted in cases of extreme malignity.

to the opinion of nearly all the most enlightened physicians from Hippocrates down to Sydenham, that fever depends on a vitiated state of the fluids, it was further maintained by Cullen, that it often arises from cold, the depressing emotions, and mechanical injuries, without the introduction of any morbific matter into the blood; consequently, that it is not owing to changes in the state of the fluids, but depends chiefly on some cause acting on the nervous system, or primary moving powers of the animal economy, and thus producing a spasmodic state of the extreme vessels. But I have shewn that whatever tends to diminish the functions by which the blood is formed and depurated, must very soon derange its healthy properties, whether it be cold, the depressing passions, concussion of the brain, an impoverished diet, or impure air.

*That all the varieties of fever are modifications of the same disease, and arise from different degrees in the intensity or duration of the causes which produce them, has been already suggested in a preceding chapter of this volume;** and will further appear from the following general facts: —

* I have shewn that diseases of the respiratory organs predominate in the higher latitudes, especially during the colder months; but that the various forms of fever, cholera, dysentery, diarrhœa, and hepatitis, prevail to the greatest extent in hot climates and seasons, owing to the operation of a high temperature and a vitiated state of the atmosphere, both of which diminish the supply of heat by respiration. It is therefore evident, that the first class is owing to a *loss*, and the second to a *deficient supply*

1. That both quartans and tertians change into quotidians, and the latter into the continued form of fever, which assumes the typhoid or inflammatory type, according to the constitution of the patient, and the more or less depressing tendency of the predisposing causes:—

2. That in cases of intermittent fever, the hot stage is always protracted longer than usual, before passing into the type of more frequent repetition, or the continued form:—

3. That there is a gradation in the malignity of fever, and debility of the patient, from the quartan, which is the mildest of the intermittents, and therefore has the longest interval, to the most deadly forms of typhus, yellow fever, and plague:—

4. That in temperate climates, intermittents

of the animating principle. The most remarkable difference between them is, that in the former, the loss of heat is generally local, superficial, or of short duration; so that if soon restored by artificial warmth, a speedy recovery may be expected; whereas in diseases brought on by excessive heat and impure air, the vital properties of the blood are more seriously impaired, than by the sudden or partial abstraction of caloric. But if from exposure to external cold, the function of respiration be permanently diminished, as in pneumonia, bronchitis, laryngitis, or pleurisy, the vital properties of the blood are impaired in the same manner, and often to the same extent, as if produced by malaria, or any other morbific agent. In short, however various the remote and exciting causes may be, the essential symptoms are the same in all diseases, and are owing to a loss or deficient supply of the animating principle.

prevail in spring, remittents in the early part of summer; and after the powers of life have been exhausted by long exposure to impure air of a high temperature, they become merged in the continued form of fever:—

5. That the most malignant varieties of continued fever are still more prevalent in tropical and warm climates, where the predisposing causes are more intense and constant in their operation: but

6. That in all climates and seasons very fatal forms of continued fever are generated by constant exposure to the concentrated malaria of crowded dwellings, poor houses, hospitals, prisons, and other ill ventilated dwellings; or from concussion of the brain, compound fractures, lacerations, and other violent injuries,—all of which tend to diminish respiration, impair the vital properties of the blood, and bring on a chill:—

7. And lastly, that the causes of intermittents operate with less intensity, or for shorter periods of time, than when they produce the continued form of the disease, is demonstrated by the fact, that, in the former, the paroxysm runs its course in *five*, *ten*, and *fifteen* hours, on an average, after which there is a complete intermission of all the symptoms.

But I have already shewn, that all the predisposing and exciting causes of disease tend to produce a vitiated condition of the blood. Nor

is it possible that any serious and permanent deviation from health can exist so long as every part of the body is supplied with a sufficiency of good arterial blood. And that the different forms of fever depend on the extent to which the vital properties of the blood are impaired, would appear from the following facts :—

1. That the paroxysm is shorter, and the interval longer, in quartans than in tertians, in which, again, the paroxysm is shorter and the intermission longer than in quotidians; whereas the continued form of the disease lasts for many days or weeks, with slight remissions : —

2. That in all the milder forms of fever, the blood exhibits nearly the same phenomena when drawn from the body as during health, except that it coagulates more slowly, and therefore usually presents a buffy coat, or what has been called the inflammatory crust :—

3. That in typhus, yellow fever, plague, and all the forms of malignant continued fever, (as in blue cholera, tetanus, hydrophobia, and the latter stages of pneumonia,) the blood is so far altered from its natural state, that it requires from thirty minutes to an hour or longer to coagulate in a very imperfect manner; while in the worst cases it exhibits either a preternaturally viscid, or a dissolved and putrescent state :—

4. That the blood of individuals exposed to a pestilential atmosphere is found to be in a highly

diseased condition before any formal attack of fever, as proved by the experiments of Dr. Potter before cited, and by those of Dr. Stevens, in the marshy districts of New York.

But it still remains a problem, *why the duration of the cold stage is inversely as that of the hot?* This question has been the gordian knot of pathology for above two thousand years. For the purpose of placing the subject in as clear a light as possible, I shall proceed to shew that in catarrh, which may be regarded as the mildest form of fever, the chill, or stage of depression, is longer than in the quartan, and diminishes in duration through the tertian and quotidian, until we arrive at the continued form of the disease.

In the first place, then, if an individual in previous good health be exposed for some time to a cold wind, damp night air, a shower of rain, or a draft of air while sitting in a cold room, the temperature of his body is gradually reduced below the natural standard; by which more or less of a chill is produced, the action of the heart diminished, perspiration checked, the various secretions somewhat deranged, and the vital properties of the blood to a certain extent impaired. But as the nutritive properties of the blood and its power of maintaining the secretions are diminished in a very slight degree, it is often from twelve to twenty-four, or even thirty-six hours, before there is any perceptible fever, which goes

off in a very short time after the circulation and activity of the emunctories have been restored, by which the blood is depurated; and does not return again without a repetition of the exciting cause, for the obvious reason that the blood has returned to its natural state.

But if an individual be exposed for some time to malaria of sufficient intensity to impair the vital properties of the blood in a mitigated degree, and then to a shower of rain, or some other exciting cause calculated to bring on a chill, the latter continues for a longer or shorter period, according as the vital properties of the blood have been previously more or less deranged, which depends on the duration or intensity of the predisposing causes. When these have been moderate, the cold stage lasts for one or two hours, because the vital heat obtained by respiration continues to unite the blood with the solids for some time after the chill has commenced: yet as the blood becomes sufficiently deranged during the stage of depression, to arrest or greatly diminish the nutritive process, whatever amount of heat is not transferred to the solids, accumulates, and brings on the hot stage, which continues until the blood is restored to its former state, when there is a complete intermission of all the symptoms. But if the patient remain exposed to the predisposing cause of the disease, the paroxysm returns at stated intervals of one,

two, or three days, unless prevented by the use of bark and other tonics, or by employing the hot bath two or three hours before the period of the cold stage. And as the vital properties of the blood are less impaired in quartans than in tertians, the paroxysm is shorter, while the intermission is longer, in the former than in the latter. For the same reasons, the cold stage is longer in tertians than in quotidians, and longer in the latter than in the continued form of fever; while the paroxysms become longer, and the intermissions shorter, until the latter wholly disappear.

But when individuals have been exposed for a considerable time to the concentrated malaria of pestilential districts, crowded and ill ventilated dwellings, poor houses, transport ships, or prisons, the vital properties of the blood are so far impaired, that almost immediately after the commencement of the cold stage, and often before it is completely formed, the fever comes on. And as it is impossible that it should cease before the nutritive properties of the blood are restored, it continues with only slight remissions till the termination of the disease, or the death of the patient. When the exciting cause is extremely virulent, as in the black hole of Calcutta, the blood is so far vitiated in the course of a few hours, or perhaps even a shorter time, that the chill is so quickly followed by fever as to be scarcely perceptible. When the streams of life have been

thus vitiated, many days or weeks are required to bring about their restoration to a healthy state; and when the blood has been once thoroughly disorganized, the physician can do little more than palliate the most urgent symptoms, which are generally followed by death.

Thus it is evident, that there is a progressive deterioration of the blood, from the mildest catarrh and quartan ague, to the most malignant forms of synochus, typhus, yellow fever, and plague. But why does the chill that ushers in the fevers arising from concussion of the brain, compound fractures, and other serious injuries, often remain from sixteen to thirty-six hours? And why does the fever assume the continued form?

The most probable reason is, that before the injury was received the blood was in a healthy state; so that, although respiration is sufficiently diminished to cause a reduction of temperature, weak pulse, and cold extremities, it is some time before the nutritive process is sufficiently arrested to produce fever. But as the vital properties of the blood are necessarily impaired to a considerable extent during the stage of depression, it cannot be restored to its former state for several days, during which time the fever continues without any intermission, and assumes the typhoid or inflammatory type, according to the constitution of the patient and the extent of the injury. It must, however, be observed, that if, before receiving the injury, the patient has been exposed

to some of the other predisposing causes of fever, it follows the cold stage much sooner, and is proportionally more difficult to resolve, because the blood is in a more vitiated state. Nor can it ever be restored to a healthy condition otherwise than by promoting its free circulation through the lungs, where it is formed, and the evacuation of whatever is superfluous or injurious from the skin, kidneys, and bowels.

It still remains to inquire why the cold stage of fever comes on generally in the forenoon, or far more frequently than in the afternoon; and why in the continued form of the disease, there is a morning remission?

The solution of these queries will be found in the fact, that respiration is always very much diminished during sleep, and arrives at the minimum about midnight, when all the energies of life are proportionally reduced: so that as the coldest part of the twenty-four hours is just before sunrise, if the body be not well covered, or its temperature maintained by artificial warmth, the chill comes on at an early hour, or sometime before mid-day. In accordance with this fact, it has been observed, that in a large majority of cases the attack of epidemic cholera was during the night, or early in the morning.

If the healthy properties of the blood are not entirely restored after the first paroxysm, (which is seldom the case,) or if the patient be still exposed to the primary cause of the disease, it is repeated

about the same time of day, at intervals of twenty-four, forty-eight, or seventy-two hours, according to the intensity of the remote cause, the degree of exposure, constitution of the individual, &c. And as the preternatural temperature of continued fever is always diminished for a time, if not permanently, by cold ablutions,—so does it abate during the coldest part of the twenty-four hours, as in the morning remission, which is promoted by the stillness and darkness of the night, and repose of the patient, who is still more relieved if he obtain a little sleep, however imperfect it may be.

The predisposing and exciting causes of apoplexy and paralysis are generally the same as those which produce fever; with this exception, that in the former, they operate more immediately on the brain.* For example, it was long ago observed by Dr. Heberden, that apoplexy is far more prevalent during either excessively hot or cold weather than at any other time, *ceteris pari-*

* According to the best writers on pathology, the predisposing and exciting causes of apoplexy and paralysis are, whatever tends to diminish the energy of the brain; such as the depressing emotions of grief and anxiety, intense and long continued study, intemperance in the use of fermented liquors, the fumes of lead, the long use of mercury, exposure to fatigue, impure air, excessive loss of blood, disease of the heart, congestion of the lungs and abdominal viscera, the narcotic poisons, and concussion of the brain,—all of which diminish respiration, impair the vital properties of the blood, and weaken its circulation through the brain. It is also worthy of special notice, that the symptoms of apoplexy correspond very nearly with those which mark the cold stage of

bus. At New York, where the extremes of temperature are greater than in Europe, the mortality during the severe winter of 1795, exceeded that of the following mild winter in the ratio of 52 to 31; and it is proportionally greater during the hottest part of summer than in spring, autumn, or even a mild winter. We have also seen from the recent Reports of the Registrar General, as digested by Mr. Farr, that the mortality from apoplexy and paralysis has been from 30 to 50 per cent. greater in London during winter than summer, which is always comparatively mild in Great Britain, where typhus fever is also more prevalent and fatal during winter than any other season. This is more especially the case in Ireland, where, owing to the want of suitable nourishment and clothing among the poor, about one fourth of the whole mortality is caused by typhus, which in nearly all cases is brought on by the immediate influence of cold, according to Dr. Mac Cormack.

cholera, and the more malignant forms of intermittent fever, which are ushered in with the same congested state of the brain, viscid condition of the blood, coma, and loss of sensibility. The numbness of ague must also be regarded as a mitigated and temporary species of paralysis, which is often brought on by exposure to cold alone. That apoplexy is owing to congestion of the brain, and not to an increased flow of blood to that organ, is evident from the experiments of John Hunter, who found on opening the temporal artery during a fit, that the blood was dark and viscid, as in cases of obstructed respiration from exposure to the mephitic gases, immersion under water, and strangulation; but gradually changed to a bright hue as respiration became more free.

And that the most malignant typhoid fever is generated by the influence of cold, without malaria, is sufficiently attested by the records of medicine; especially in the United States, where, about thirty years ago, an exceedingly fatal disease, termed cold plague, or pneumonia typhoides, prevailed throughout the western country, and some parts of New England, during the middle and latter parts of winter.* It is not sufficiently understood by the community, that daily or frequent exposure to cold alone, until the general circulation is enfeebled, and respiration diminished, (as shewn by the coldness of the extremi-

* The most prominent symptom of the disease, as in the more malignant forms of typhus in Europe, was a congestion of the lungs and abdominal viscera, with a dissolved condition of the blood. In all such cases, the obvious indication is to persist in the employment of fomentations, the warm bath, or the application of dry heat, together with warm cordials, until the action of the heart, and circulation through the lungs are roused, the vital properties of the blood improved, and the secretions restored. The same observations apply equally to cholera, tetanus, hydrophobia, and other spasmodic diseases,—all of which are prototyped in the cold stage of fever. In the Medical Gazette of July, 1837, there is an account of spotted fever, attended with a livid hue of the skin, and the same viscid or dark and grumous state of the blood as in malignant cholera. After finding (says Dr. Wilson, of Middlesex Hospital,) that the ordinary treatment failed, the warm bath, with cold applications to the head, and a saline mixture composed of 30 grs. carbonate of soda, 20 grs. chloride of sodium, and 6 grs. chlorate of potass, were employed; when 17 out of 19 cases recovered;—whether owing to the stimulating influence of the warm bath, or to the saline mixture, must be left to the decision of the intelligent medical reader.

ties and blueness of the surface, in persons thinly clad,) is one of the most common predisposing and exciting causes of low and protracted fevers. For I have already shewn, that when the powers of life have been greatly reduced by impure air, the excessive heat of summer, and that of tropical climates, exposure to cool nights, damp foggy mornings, a shower of rain, or getting the feet wet, is the ordinary exciting cause of fever. It was truly observed by Cullen, that the conditions which favour the operation of cold are general debility, fasting, evacuations, fatigue, loss of sleep, the depressing emotions, and previous disease.

What is termed *coup de soleil* is only a milder form of apoplexy, brought on by over exertion under the influence of a burning sun, when the surrounding temperature is above that of the blood, —by which, respiration is so far diminished, and the power of the circulation reduced, that the brain is no longer duly vitalized, and the patient falls down in a state of apoplexy or prolonged syncope, until aroused by sprinkling water in the face, or by cooling ablutions, which tend to augment respiration, together with the nutritive process. On the other hand, when the powers of life have been reduced by age and other predisposing causes of debility, the capillaries of the lungs are paralyzed by cold, respiration and the power of the heart diminished, by which cerebral atony and congestion are induced, followed by

apoplexy, paralysis, or some other dangerous malady.

It was the opinion of Hippocrates, that coma and apoplexy are owing to a *frigidity and thickness of the humours in the brain; consequently, that they should be rarefied by heat, applied in the form of fomentations.* Nor can there be a doubt, that the proximate cause of syncope,* coma, catalepsy, epilepsy, apoplexy, and the low delirium of typhus, is a deficient supply of good arterial blood and vital heat to the brain. But under the erroneous impression that most of these morbid conditions are owing to an increased flow of blood to the brain, many practitioners resort to bleeding, which often increases the debility of the cerebral capillaries, and thus causes effusion,—an effect

* It is sometimes difficult to distinguish apoplexy from snycope, as the following case will exemplify. A clerical gentleman who had been for some time accustomed to close mental application, delivered a sermon on Sunday morning, and immediately afterwards attended a funeral, by which he was much exhausted. He then took a hearty dinner, and commenced the afternoon service, during which he fell backwards in the desk, in a state of syncope, from which he slowly recovered. Now if this gentleman had been fifty years of age or older, or if his brain had been weakened still more by previous habits of intemperance, the case would have been one of decided apoplexy, which is often brought on by a hearty meal. This operates in a twofold manner; first, by pressing upon the ascending vena cava, thus preventing the free passage of blood into the right side of the heart, and thence into the lungs; or by diverting a portion of the blood which usually circulates through the brain to the stomach, for the purpose of carrying on the process of digestion.

which is also frequently produced in other parts of the body by the loss of blood, without tending in the slightest degree to remove the proximate cause of the congestion. But in all cases of apoplexy and concussion of the brain, the powers of life are reduced below par, and require the use of remedies adapted to arouse the nearly suspended circulation; such as hot brandy, wine, or some other stimulating cordial, hot applications, alternated with cold affusions and fresh air, with a view of augmenting respiration.

It was again observed by Hippocrates, that "*nature is the best physician in disease*,—that untaught and unlearned, she knows and does what is best." But it is worthy of special notice, that by *nature* he meant the principle which animates the universe, and performs all the operations of the living body. He also maintained that the whole art of medicine consists in knowing how and when to remove what is superfluous, and to add what is deficient: or, in the version of Vanderlinden, "Medicina nihil aliud est nisi adpositio et ablatio—ablatio quidem eorum quæ excedunt—adpositio vero eorum quæ deficiunt." (De Flatibus, s. iii. et Omnia Opera Hippocratis.)

Bacon also observes, that "man whilst operating, can only apply or withdraw natural bodies; whilst nature internally performs the rest." (Novum Organum.)

Again, says Godfrey Herder, "in what does

the art of the physician consist, but in acting as the servant of nature, and hastening to the aid of the multifariously working powers of our organization?" Nor can there be a rational doubt, that the highest wisdom of the physician is to follow the indications of nature in the prevention and treatment of disease. But how can he do this without knowing the cause of all the vital functions, and the mode in which it maintains them in health? How can he restore the different organs to their natural state, without knowing what is best calculated to augment, diminish, and thus modify all their actions?

Although but vaguely understood, the fundamental doctrine of the ancients in regard to the curative powers of nature, has been adopted by a large majority of modern pathologists; and especially by the illustrious Sydenham, who maintained that fever is an effort of nature to correct or expel morbific matter from the blood, by vomiting, purging, sweating, urine, spontaneous hemorrhage, or some other evacuation;—that the plague is a complication of actions to throw out some offending matter through the emunctories, or by the formation of buboes and other eruptions; while gout is a contrivance of nature to purify the blood, and purge the recesses of the body. Nor is it unworthy of notice, that the *Archeus* of Paracelsus and Van Helmont, the *vis Naturæ* of Harvey, the *animal spirits* of the later mechanical

and chemical physicians, the *anima* of Stahl, the *nervous fluid* of Willis, Hoffman, Baglivi, Boerhaave, Barthez, and Cullen, like the celebrated *vis medicatrix naturæ*, were only different names for what Hippocrates termed θερμον, πνευμα, and φυσις, which they never identified with any known principle capable of scientific demonstration. It is therefore not surprising that none of their theories have been found capable of explaining any of the vital functions in either health or disease.

It must be admitted, that without the assistance of nature, or what has been termed the *vis medicatrix naturæ*, the physician could perform no cures, any more than the farmer could raise corn and grass without the heating power of the sun. But this doctrine was carried to a vicious and dangerous extent by many of the older practitioners, who were in the habit of treating fever by hot applications, to the exclusion of fresh air, cooling drinks and ablutions. Even at the present day, it is maintained by Parry and some other pathologists, that not only fever and inflammation, but coma, convulsions, apoplexy, epilepsy, paralysis, chorea, dropsy, dysentery, diarrhœa, and the formation of tubercles, are efforts of nature to counteract the influence of some morbific agent.

So far is this from being true, that all diseases are attended with a diminution of the *vis medica-*

trix naturæ, which, as I have already shown, is merely another name for the aggregate of the actions by which blood is formed, purified, and prepared to maintain the functions in their natural state. But the essential condition of fever and inflammation is a derangement of the nutritive process, and of all those actions by which the healthy powers of life are sustained. At the same time, it must be admitted, that the tendency of the hot stage is to augment the action of the heart, and the circulation through all parts of the body, by which the previous torpor of the cold fit is overcome, and the sweating or secreting stage brought on, as in the various grades of intermittent fever.

It must also be admitted, that emetics and purgatives induce a spasmodic action of the stomach and bowels, by which the offending agents are removed; but it is by weakening the parts on which they operate, and thus diminishing the power of nature, that they produce these effects, which also follow an excessive loss of blood, and the employment of the cold bath when carried too far. It cannot therefore be said with reason, that the nausea, vomiting, and convulsions thus induced, are salutary efforts of nature to counteract the operation of morbific causes which are purely negative. Nor is it true, that the effusions which take place during inflammation, dropsy, and apoplexy; the profuse discharges

from the bowels in dysentery and diarrhœa, or the spasms of cholera, tetanus, and hydrophobia, exert the slightest tendency to remove the proximate cause of these symptoms, which owe their existence to debility, and a diminution of those actions that constitute the *vis medicatrix naturæ.*

On the erroneous supposition that diseases arise from an effort of nature to expel some morbific agent from the blood, the *Hydropathists* cause their deluded patients to remain exposed to the cold bath from one to two or three hours daily, until fever is induced, or the body is covered with eruptions and ulcers,—which are evidently produced by the influence of cold, and must be cured by overcoming the weakened condition of the capillaries, as in all cases of congestion and inflammation.*

* It is a curious fact, that we are indebted to an ignorant empiric for the elucidation of a most important principle in pathology; viz. that cold alone, or the abstraction of caloric from the body, by the continued employment of the cold bath, cold wet bandages, and by drinking enormous quantities of cold water, is capable of producing a vitiated condition of the blood, dryness and roughness of the skin, herpes, boils, ulcers, abscesses, violent headache, dizziness, tremor of the limbs, (a species of palsy,) nausea, vomiting, diarrhœa, and fever,—all of which are regarded as salutary efforts of nature to expel morbific matter from the blood. (See Claridge on Hydropathy, pp. 122. 196. 214. 239.) And yet the practice is now extensively employed for the cure of nearly all diseases, including inflammation of the lungs, rheumatism, and gout. Claridge says expressly, that few individuals pass more than five or six weeks under the treatment of the cold water system, *without being charged with eruptions and boils:*—that

Moreover, that cold is a very general predisposing and exciting cause of scrofula, scurvy, erysipelas, scarlatina, measles, small-pox, and all other eruptive diseases, whether specifically contagious or not, would appear from the late Reports of Major Tulloch, on the diseases and mortality of the British troops in various parts of the world; according to which eruptive disorders are comparatively rare in tropical and warm climates. So that notwithstanding nosologists have described

Priessnitz causes his patients to drink cold water until *sickness* or *diarrhœa* is produced; which proves, he observes, that "the stomach contains the remains of diseases which the water has disturbed; consequently, that it is requisite to drink more," as Dr. Sangrado would say. (p. 109, 1st edition.) Verily, this barbarous system has been appropriately termed *Hydropathy*, which literally means the *water disease*, instead of the water cure. That the recoveries at Graefenberg, (which have been shamefully exaggerated,) have been owing chiefly to good air, exercise, friction, sweating, and *leaving off the cold water treatment after a few weeks*, would appear from the statement of Claridge, that when fever is produced, or extensive suppuration takes place, "the baths are suspended during the discharge of these humours; by which the system is much benefitted." (p. 118.) And that it would be rapidly destructive of life in old people, very young children, and all individuals of feeble constitution, is still more certain. It was stated the other day, in a report by a teacher in one of the London poor houses, that *during cold weather the children were cut down like skittles*, on leaving the windows of the school-room open for the admission of fresh air. The only patients I have seen, who had made a full trial of hydropathy, were an aged gentleman in delicate health, who expatiated on its many virtues till the last day of his life; and a middle aged gentleman, in whom it produced a permanently sore leg, which he seemed to regard as a decisive proof of its salutary influence in carrying off bad humours.

several hundred specific maladies, exclusive of varieties and combinations, it is highly probable that they are all modifications of one and the same disease, diversified by the parts affected, the nature, intensity, or duration of the causes which produce them, and by varieties of constitution.

*This much is absolutely certain, that all the cardinal symptoms of every constitutional fever may be traced to a loss or deficient supply of the animating principle, and a vitiated state of the blood.** For

But the practice of remaining for hours, every day, in a sitting bath at 64°, and drinking from ten to twenty or thirty glasses of cold water, is so extremely painful to endure, and is so completely at war with the natural instinct of self-preservation, that it is not likely to become general, nor continue long, except among fanatics, who in all ages have been the willing victims of self-torture. It must, however, be admitted, that when patients do survive this treatment, their general vigour is augmented. For I have proved that a rapid loss of caloric, whether caused by exposure to cold, or by over exertion, is attended with a proportionally rapid waste of the solids, and creates the necessity for a large amount of food to supply the waste, and support the process of respiration, which, like sanguification, secretion, and nutrition, is so far augmented as to produce a rapid renewal of the whole body, as during the period of growth in young animals, and convalescence after emaciation from illness. (See pp. 713. 881. 941.)

* So long as there is a free circulation of good arterial blood through the lungs, pleuræ, trachea, larynx, and schneiderian membrane, there can be no phthisis, pneumonia, pleurisy, croup, laryngitis, influenza, nor even the slightest catarrh. So long as the abdominal viscera are supplied with an abundance of rich arterial blood, there can be no torpor of the stomach, bowels, and liver,—no loss of appetite, dyspepsia, cardialgia, colic, gastritis, hepatitis, dysentery, diarrhœa, constipation, nor any serious

I have demonstrated that so long as the blood is in a condition to combine with the solids and maintain the various secretions, there can be no preternatural temperature of the body; because the vital heat is transferred to the several tissues, and expended in preserving their activity, as fast as it is obtained by respiration; and that all constitutional diseases are invariably attended with more or less fever, except when respiration is too far diminished to produce reaction, as in cholera, cold plague, the worst forms of typhus, tetanus, hydrophobia, and other low diseases.

But all the predisposing and exciting causes of disease tend to diminish the process of respiration by which the blood is generated, and that of the emunctories by which it is depurated, until it is

derangement of the chylopoietic organs. So long as the brain and nerves are freely supplied with rich arterial blood, there can be no stupor, delirium, head-ache, apoplexy, hemiplegia, local paralysis, neuralgia, loss of sensibility, nor any important disorder of the sensorial functions,—if we except monomania, which, in an endless variety of ways, has been supposed by some to afflict a large proportion of the human race, including poets, many distinguished philosophers, and founders of systems. At the same time, I am inclined to believe with Hippocrates, that nothing contributes more to a sound state of mind than good blood. "Opinor autem inter omnia quæ in corpore sunt, nihil magis ad prudentiam conferre quam sanguinam." (De Flatibus, sect. xx.) There is a real foundation in reason for the importance attached to good blood, in a moral and intellectual as well as a merely physical point of view. The want of it begets ill temper and selfishness in persons who at other times are amiable and benevolent.

no longer in a condition to nourish the brain, nerves, muscles, and other tissues, when a very slight exposure to fatigue, cold, or some other exciting cause, brings on a chill, stagnation of blood in the lungs, torpor of the skin, kidneys, bowels, and a retention of nearly all the effete matter of the body in the blood, which is thus still further vitiated. The manner in which the blood is depurated by the various excretions, and vitiated by their retention, may be strikingly illustrated by the sanatory police of London. For example, the sewers of that immense city perform the same office in carrying off its excrementitious matter as do the skin, kidneys, and bowels, which are the natural sewers of the living body. If the supply of fresh water were cut off, and the excretory ducts of London were obstructed for a few months, or even weeks, it would be very soon visited by the plague or some fatal epidemic, as in former times, when suffered to remain in a filthy state.

I have already shewn, that the hot commences sooner after the first symptom of the cold stage, and continues for a longer time, in proportion to the previous vitiation of the blood:—that when the latter is slight, the cold stage remains from one to two hours or longer, and the paroxysm about five hours, after which there is an intermission of all the symptoms, excepting slight debility, until the fourth day, as in quartans:—

that when the predisposing causes have been of greater intensity, and the vital properties of the blood have been still more impaired, the fever comes on sooner after the chill, (which is thus shortened,) and continues for about ten hours on an average, or until the nutritive properties of the blood are sufficiently restored to bring on the sweating stage, when there follows an intermission that continues until the third day, as in tertians: —that when the predisposing causes have been of still greater intensity, and the blood has been proportionally vitiated, the fever comes on sooner again after the chill, (which is still further shortened,) and continues about fifteen or sixteen hours, as in quotidians; after which there is a brief intermission until the next day:—and lastly, that when from exposure to causes of greater intensity, the sanguineous fluid has been still further changed from its natural state, the chill is scarcely formed before the vital heat obtained by respiration ceases to combine with the solids, and accumulates so as to produce the preternatural temperature of fever, which continues without any intermission till the termination of the disease.

I have moreover shown, that the debility and general malignity of the fever increases from the quartan, (which very seldom if ever proves fatal, except from improper treatment,) to the quotidian, which often passes into the continued type. Were it not that in all cases of fever the

blood has been previously altered from its natural state, it might be cut short at once by employing the hot bath an hour or two before the expected chill, which would thus be prevented. It also follows, that as the blood is always deteriorated during the chill, and improved by the augmented action of the lungs during the hot stage, it must be a matter of primary importance to follow the indication of nature, and prevent the recurrence of the cold stage by means of the warm bath, or a suitable application of dry heat. And it is highly probable, that all the milder forms of fever would be thus arrested very soon ; while those of the continued type would be proportionally mitigated and shortened in their duration ; for by this practice we should strike at the very root or proximate cause of the disease, instead of prescribing at random for this or that symptom.

Much labour has been expended within the last few years in post mortem examinations, with a hope of discovering the primary seat of fever. But although a certain amount of valuable information has been thus acquired, we might as well seek for the cause of hurricanes in the desolation they produce, as for the *ratio symptomatum* of fever in local irritation, congestion, or inflammation, without ascertaining "*the first link in the chain of diseased effects.*"

The primary seat of fever is not the brain, spinal marrow, ganglionic nerves, the solar plexus,

(which has been recently represented as the centre of vitality,) the stomach and bowels, Peyers glands, nor in any particular organ, but in all parts of the body, and especially in the blood, which is the life of the solids, (as maintained by Moses, Hippocrates, and Harvey,) the alpha and omega of health. The physician who is ignorant of this, has yet to learn the grammar or first elements of the great science which he professes.

The whole theory of medicine must be founded on a knowledge of the mode in which the animating principle operates in health, and of all the physical agents that diminish, augment, or in any way modify the functions of respiration, sanguification, secretion, nutrition, sensation, and muscular motion. I would therefore repeat what was said in a previous chapter, that *if anything deserves the name of universal remedy, it is the principle of life itself, which converts food into blood, fashions every part of the body as if by a divine intelligence, renews its composition when wasted by illness, heals wounds, ulcers, and abscesses, expels whatever is superfluous or injurious, connects all the organs into one harmonious system, and maintains it in a state of health*:—that the celebrated *vis medicatrix naturæ* is only another name for the *vis caloris*, a perfect knowledge of which would give to mankind a more effectual and certain method of curing, or rather of preventing

disease, than all the drugs of the materia medica, which would be reduced to a very small compass; for we have seen that many of the *heroic* remedies, as they are called, impair the vital properties of the blood, and operate as morbific agents.

It may be received as an axiom, that so long as respiration is properly maintained by pure air, nutritious aliment, and a cheerful state of mind, while the temperature of the body is kept at the natural standard by avoiding damp night air, showers of rain, wet feet, chilling winds, cold rooms, over exertion, intemperance, &c. there could be no serious aberration from the healthy state. But men have yet to learn that all their vital functions are more or less modified by every change of their temperature, and the latter by everything which operates upon them, whether for good or evil:—that "a single excess blurs and confuses the music written on our minds,—that an untimely vigil weakens and bewilders the delicate minister to our inner temple." (Willis.)

To remove the causes of disease when practicable, and to assist nature when unable to relieve herself, is the province of the enlightened physician, whose title is derived from the word φυσις, and implies that he is the priest or servant of nature, without which he can perform no cures. The salutary agency of heat is implied in the words *health* and *healing*, which may be traced to *Helios*, which signified the sun among the

Greeks, Phœnicians, Egyptians, Hindoos, and ancient Celtic nations. Apollo, who was the god of medicine, was also a mythological personation of the sun, which is manifestly the fountain of life, and therefore of health, throughout creation. Nor is it unworthy of notice, that the name of Æsculapius (who is represented as the son of Apollo, and founder of the healing art in Egypt,) was derived from three oriental words, *Es*, *kul*, and *ab*, meaning *heat*, *the universal parent*, or generator of life, and preserver of health. An ancient prophecy of his life and actions is beautifully described by Ovid, as in the following lines translated by Addison :—

> " Hail, great physician of the world ! * *
> * * * * who, in years to come,
> Shall heal the nations, and defraud the tomb !
> Swift be thy growth, thy triumphs unconfined,
> *Make kingdoms thicker, and increase mankind.*"
>
> (Met. b. ii. l. 640.)

We owe it to the bounty of Providence, that whatever is most conducive to permanently agreeable sensations is most favourable to health. In temperate climates, summer and autumn are the most *delightful* seasons of the year, and the most *healthy*. But as they are disagreeably hot within the tropics, they are unfavourable to health and long life, while winter is pleasant and salubrious. There is nothing more *delightful* to the mind than hope, friendship, love, and the conscious-

ness of well doing, nor any thing more conducive to *health* and *longevity;* whereas there is nothing more surely inimical to both than the *painful* emotions of fear, grief, jealousy, intense anxiety, and fell remorse. There is nothing more pleasant and invigorating than moderate exercise of all the organs; and when they are fatigued, there is nothing more grateful and refreshing than sleep. There is nothing more agreeable and salutary than fresh air, pure water, good bread, milk, eggs, and other animal food when we are hungry, with a due proportion of vegetables, and of ripe fruits in their season.

Again; when the temperature of the body and all the energies of life are reduced below the normal standard, as during the cold stage which ushers in nearly all diseases, or when the vital heat has been unduly expended by muscular exertion; what is so delightful and well suited to rouse the torpor of the nearly suspended functions as the agent which causes the heart to beat, the stomach to digest, the muscles to contract, the nerves to feel, and the brain to think. Or when the vital properties of the blood have been impaired by any of the remote and exciting causes of disease, what is so likely to restore its healthy state as the various means of augmenting respiration, by which it is renovated. And when owing to an interruption or diminution of the process by which the animal heat obtained in

the lungs is transferred to the solids, the temperature of the body has been raised above the normal standard, as during fever, what so delightful and calculated to restore the nutritive process as fresh air, cooling ablutions, with refrigerating beverages, lemonade, soda water, tamarind water, l'eau sucrée, orange juice, &c.?

The great secret of a successful treatment consists in knowing what remedies are best adapted to restore the various functions to their natural state, and to promote the evacuation of morbid excretions, without impairing the vital properties of the blood. And as nearly all diseases are attended with more or less torpor of the bowels, mild aperients are often required, or even active purgatives, when the alvine excretions have been long retained.

To the honour of the medical profession, the most enlightened physicians of the present day, and especially those who attend the higher classes of society, are more sparing in the use of the lancet, leeches, the scarificator, and poisonous drugs, than formerly. At the head of this class in England stands Sir James Clark, whose judicious practice has been justly rewarded by the patronage of the Queen,—a selection which is alike honourable to both. But unfortunately for the mass of mankind, such is their ignorance in regard to the laws of health, that if their medical attendant do not dose them plentifully with nauseous com-

pounds, they are almost sure to desert him, and resort to some unscrupulous empiric, who mendaciously takes to himself the credit of all the *recoveries* performed by nature, and impudently calls them *cures*.

Theory of Inflammation.

It was maintained by Boerhaave and Gaubius, that the proximate cause of inflammation is a viscid state of the blood, and an obstruction to its free passage through the capillaries of the diseased part. But this simple and almost self-evident view of the subject was rejected by Cullen, who observes, that "the phenomena of inflammation all concur in shewing, that there is an increased impetus of blood in the vessels of the affected part:—that as the proximate cause of fever is a spasm affecting the extreme vessels, and as every considerable inflammation is attended with symptoms of fever, it seems probable that a spasm of the extreme vessels is also the immediate cause of topical inflammations:—that the phlogistic diathesis consists in an increased tone, or contractility, and perhaps in an increased contraction of the muscular fibres of the whole arterial system." (Practice of Physic, Sections 239. 243. 247.)

That inflammation and fever are modifications

of the same radical disease, and that both are generally attended with increased action of the heart, cannot be denied. It might even be said, that inflammation is a local fever, and that idiopathic fever is a general inflammation: for they are both ushered in with more or less of a cold stage, which is followed by a preternatural elevation of temperature. Nor is it less certain, that all extensive or serious local inflammations are attended with general fever, the leading symptoms of which are essentially the same as if produced by malaria.

The opinion that local inflammation depends on increased action of the capillaries, and the circulation of a greater amount of blood through them than in the healthy state, was embraced by John Hunter, Abernethy, Richerand, Gendrin, Parry, Kaltenbrunner, James, and Lawrence.* On the other hand, the views of Boerhaave and Gaubius have been ably defended by Vacca, Allen, Dr. Lubbock, Dr. Philip, Dr. Hastings, Dr. Billing, and some others. The most important experiments on the subject are those of

* The opinion of Mr. Lawrence, that inflammation depends on increased action of the affected part, seems to have been confirmed by the experiment of simultaneously opening a vein in both arms of a patient who had inflammation in one hand, when a much larger amount of blood flowed from the diseased side than from the other. But may not the vein or the orifice have been larger in the one case than in the other? However this may have been, it is certainly not true that blood flows more freely from a

Dr. Philip, who found that when inflammation was produced in the transparent web of a frog's foot, the fins and tail of fish, or in the mesentery of a rabbit, by mechanical or chemical irritants, the small vessels became enlarged, congested with red blood, and its circulation more and more languid, until at length it entirely ceased. He also found, that when caused by exposure to a cold current of air, the diameter of the vessels was diminished, and the velocity of the blood through them increased, on directing upon the inflamed part the concentrated rays of the sun from the concave reflector of his microscope. (Exp. Inquiry, pp. 280. 288. 297. 381.) Yet this last experiment seems not to have called the attention of Dr. Philip to the important and very obvious conclusion, that caloric is the cause of circulation; and he maintains that blood is impelled through the capillaries by virtue of their own action; so that when weakened by cold, mechanical or chemical irritation, the velocity and momentum of the blood through them must be diminished, or even wholly arrested in extreme cases. But I have proved that the im-

vein during inflammation than at other times, except when the action of the heart and general circulation are greatly augmented. On the contrary, in the worst forms of inflammation, it flows at first with difficulty; shewing that its motion has been retarded, and that the power of the heart is inadequate to propel it onward, until a portion of it is removed, when it runs more freely, and changes to a brighter hue.

mediate cause of capillary circulation resides in the blood, and is owing to the transition of caloric from the blood to the solids, as in the process by which various fluids are forced through the pores and small tubes of dead matter; while it is admitted by many of the most accurate microscopic observers of the present time, that in their natural state no action of the capillaries can be perceived.

Again; that inflammation is always attended with diminished circulation in the affected part, would appear from the following general facts:—

1. That all the predisposing and exciting causes of inflammation produce debility, such as cold, the narcotic and other poisons, a severe burn, mechanical injuries, &c.*

* Dr. G. Gregory observes, in his work on the Practice of Physic, that by far the most common exciting cause of rheumatism, gastritis, enteritis, dysentery, diarrhœa, and every description of internal inflammation, is cold,—the modus operandi of which, he says, is still involved in the greatest obscurity. (pp. 155. 259.) But we have seen that the invariable effect of cold, or a deficient supply of caloric, is to diminish the circulation of any part,—causing obstruction, effusion, tumefaction, tension, and more or less pain. Nor is it less certain, that when they do not destroy life immediately, hydrocyanic acid, conia, oxalic acid, arsenic, bichloride of mercury, and all the more active poisons, produce congestion or inflammation of the stomach and other parts to which they are applied; while it is worthy of notice, that the only difference between simple congestion and inflammation is, that the former is attended with little or no reaction, and no increase of temperature in the affected part, owing to diminished respiration and languor of the heart.

2. That persons of feeble constitution are more liable to inflammations than the vigorous and sanguine, while it is equally certain that they generally fall upon the weakest organs of the same individual.*

3. That if the blood were conveyed through an inflamed part as rapidly as it is sent to it from the heart, there could be no accumulation of fluids, and no congestion or swelling of the part.

4. That as the pulsating force of the radial artery is increased by compressing it at the wrist; and as violent throbbing of the heart is the immediate consequence of tying the aorta of an animal,

* For example, we have seen that individuals of narrow chest and weak lungs are far more liable to catarrh, influenza, pneumonia, phthisis, and all diseases of the respiratory organs, than such as have a large thorax, sound lungs, and robust health:—that when the stomach, bowels, liver, and other abdominal viscera, have been weakened by exposure to a very warm or impure atmosphere, (or even the depressing emotions, fatigue, and improper nourishment,) they are extremely liable to congestion and inflammation, which are brought on by exposure to slight degrees of cold, or damp night air, as shewn by the prevalence of cholera, gastritis, dysentery, diarrhœa, and hepatitis, in hot climates and seasons. It is also well known that when the peritoneum has been long distended and weakened, as during utero gestation, and the whole system exhausted by parturition, women are very subject to peritonitis; and that when the brain is greatly debilitated by concussion, or by violent emotions of terror, grief, and other depressing passions, it is peculiarly liable to inflammation, which is likewise induced by sprains, bruises, lacerations, compound fractures, compression from a tight bandage, a severe burn, the action of caustics, and whatever disorganizes or greatly weakens the tissues.

the conclusion is inevitable, that any obstruction to the free circulation of blood must be attended with more or less throbbing of the affected part, as in all local inflammations. Hence it is, that when the brain has been seriously weakened by concussion, violent emotions of grief, or intense thinking, and the free circulation of blood through it is impeded, there is a throbbing of the carotid arteries. And hence also it is, that when torpor of the stomach, bowels, liver, and whole capillary system has been induced by impure air, want of sufficient nourishment or clothing, the depressing passions, &c. palpitation of the heart is caused by a slight degree of muscular exertion, which augments respiration, and rouses the heart to send more blood to the capillaries than can freely pass through them, until stimulated by the warm bath and other appropriate remedies.

The leading symptoms of local inflammation are tumefaction, redness or a livid hue, increased temperature, pain, and more or less throbbing of the part, with a manifest diminution of secretion and nutrition. In nineteen cases out of twenty, it is brought on by the immediate influence of cold,* which retards the circulation through the

* And it must always be remembered, that the influence of cold is relative to the size of the lungs and general strength of the constitution,—that the same temperature which diminishes respiration and the power of the heart in a feeble individual,

capillaries, and diminishes their contractility. The consequence is, that they are dilated by means of the *vis a tergo*, engorged with blood, and tumefaction induced. In the mean time, owing to the weakness and diminished cohesion of the vessels, there is an effusion of serum, lymph, and sometimes of red blood, into the cellular tissue or other surrounding parts, by which the swelling is still further increased. And as the onward motion of the blood is impeded, it is prevented from receiving the vitalizing influence of respiration; by which its nutritive properties are impaired: so that the animal heat sent to the part in combination with arterial blood, is not properly united with the solids, as during health, but given out

produces directly opposite effects on persons of sanguine temperament,—that after the muscles have been exhausted by over exertion, or an excessive expenditure of vital energy, they are far more liable to rheumatic inflammation than at other times,—in short, that the morbid effects of cold are in proportion to its influence in retarding the circulation of the part on which it operates. The more rapidly caloric is abstracted, the higher is the temperature of the body at which the loss becomes fatal, because it is not supplied by respiration. It may also be observed, that the only difference between rheumatism and neuralgia is, that the one is confined chiefly to the investing membranes of the muscles, while the other depends on inflammation of the nerves, but is sometimes united with rheumatism, which is then more painful than usual. They are both to be treated by gradually restoring the free circulation of good arterial blood through the affected parts, and not by debilitating medicines. The modern practice of dividing the inflamed nerve in tic douloureux, should be shunned as a barbarous and unnecessary operation.

in the free state, causing a local fever. Hence the redness, tension, swelling, and heat, which are attended with more or less pain, owing partly to compression of the nerves, partly to morbid sensibility produced by the preternatural temperature, and still more, perhaps, to a failure of the nutritive process, any derangement of which is always accompanied with disagreeable sensations.

But how does local inflammation induce general fever? The prevalent belief has been, that morbid action is propagated from the primary seat of injury to other parts of the body by *sympathy*, which has generally been referred to nervous influence:—that the operation of cold and moisture on the feet induces a sympathetic affection of the lungs, and thus lays the foundation of phthisis, or some other pulmonary disease:—that the loss of appetite, nausea, and vomiting, which follow a blow on the head, intense grief, and other depressing emotions, are owing to sympathy of the stomach with the brain:—that the head-ache which follows a debauch, a dose of tartar emetic, or some other noxious agent, is owing to sympathy with the morbid condition of the stomach:—that when fever is induced by a compound fracture, or any other serious injury, it arises from sympathy with the affected part:—and that when gastritis, enteritis, dysentery, diarrhœa, or hepatitis, are brought on by expo-

sure to cold, after the body has been weakened by over exertion in the hot sun, they are owing to sympathy with the skin, &c.

But the word *sympathy*, as employed by pathologists, is merely an *asylum ignorantiæ*. Sir Charles Morgan observes, that "it is a primitive law of organization which admits of no other explanation than that which shall unfold the mystery of life itself." (Philosophy of Life, p. 244.)

The modus operandi of what is called morbid sympathy, may be illustrated by the following facts. In the first place, when the feet have been exposed for some time to the influence of cold and moisture, the temperature of the whole body is gradually reduced by the abstraction of caloric, which is brought to them in combination with the blood, causing more or less torpor of the general circulation: so that if the lungs are in a feeble state, they become still further paralyzed, until congestion or inflammation is established, as in pneumonia and bronchitis, which are the usual forerunners of consumption. But as the blood is formed, renovated, and purified in the lungs, it is evident that its free circulation through them must be greatly retarded, respiration diminished, and its vital properties impaired;* so

* I have often observed that blood drawn from the arm during the advanced stages of pneumonia, bronchitis, and pleurisy, was so far dissolved as to require from thirty minutes to an hour to

that the animal heat, which in its natural state is employed in combining it with the solids, and in maintaining the various secretions, is given out in the free state, causing more or less fever, prostration of strength, head-ache, delirium, and a diseased condition of the whole body.

Again; as respiration is partly a voluntary process, it is diminished by concussion of the brain, or violent emotions of grief and other depressing passions. The consequence of which is, that the chemical function of the lungs, the supply of animal heat, sanguification, secretion, and nutrition, are greatly diminished. Owing to the weakened state of the brain, the circulation through it is impeded; and as it is no longer supplied with good arterial blood, stupor, syncope, or symptoms of apoplexy follow. When the in-

coagulate; and then very imperfectly, when it presented the same appearances as in cases of typhus and other malignant fevers. The truth is, that local inflammation of the brain, stomach, bowels, or of any important organ, whether produced by cold, mechanical violence, or the chemical agency of some poison, is attended with more or less obstruction in the affected part, by which a large amount of blood is prevented from passing through the lungs; the consequence of which is, that its nutritive properties are impaired, the secretions deranged, and general fever induced, except when the reaction is not sufficient to produce that state, as when the constitution is in a very feeble condition, and respiration greatly diminished. I have also shewn that, after a certain time, the coagulating power of the blood is more or less impaired in all cases of local congestion, inflammation, general fever, and, in fact, every form of disease. (See Book IV. Chap. iv. p. 655.)

jury has been so serious as nearly to arrest the process of breathing, the extremities remain cold, and the pulse feeble, for two or three days, or until death. And as the stomach is no longer supplied with good arterial blood, the secretion of gastric juice is arrested, causing a loss of appetite, nausea, or even vomiting. For the same reason, the voluntary muscles being no longer duly nourished, lose the power of contraction, and the healthy state of all the functions is no less certainly destroyed than by a dose of arsenic, oxalic acid, or any of the narcotic poisons, which, as I have already shewn, never produce their deleterious effects by sympathy or nervous influence, but always by impairing the vital properties of the blood. And it is equally manifest, that the hectic fever which attends phthisis, is not owing to sympathy of the whole body with the primary affection of the lungs, but to a loss of the nutritive properties of the blood.

It has been long known, that rheumatism, gout, erysipelas, and other local inflammations are sometimes suddenly removed from the surface or extremities to the stomach, brain, heart, lungs, &c. by what has been called *metastasis*, the rationale of which is no less obscure than that of *sympathy*. By far the most frequent cause of this change or transfer of disease from superficial to deep seated parts, is the local application of cold, when the body is in a feeble state. For

example, we are informed by Dr. Robert Dick, of a gentleman with gout, who kept the affected foot in cold water for fifteen minutes, when the pain and swelling subsided; but that he was soon afterwards attacked with a feeling of oppression, weight, and fullness in the region of the heart, from which he had not been able to relieve him :—and that another gentleman of feeble constitution, who was labouring under rheumatism, was persuaded by some hydropathist to use the cold bath ; soon after which he was attacked with disease of the heart and difficulty of breathing. (Lancet, Nov. 12, 1842.)

That the application of cold to an inflamed part should relieve the pain for a time, is not in the least surprising, because it *deadens* the sensibility of the part. It also diminishes the swelling by its astringent operation upon the capillaries, and by arresting the free passage of blood into them from the larger vessels. But as it reduces the activity of the circulation through the lungs, heart, stomach, and all the other organs, they are rendered more liable to congestion or inflammation, especially if previously debilitated by intemperance or the abuse of drugs. And if the brain has been weakened by narcotics, the depressing emotions, or intense thinking; vertigo, head-ache, low spirits, and even apoplexy, may be induced by undue exposure to cold. Many examples of metastasis are recorded by Arm-

strong, Parry, Scudamore, and others, from the application of cold water, and exposure to cold air, in cases of gout, rheumatism, and erysipelas, which are also produced by whatever greatly weakens the general powers of life in the more important organs.

I have already observed in a preceding chapter, that during the retreat from Moscow, the symptoms of approaching death among the French soldiers, from the united influence of cold, want of nourishment, and mental dejection, were diminished power of the heart, slow and imperfect respiration, a pale or purple hue of the surface, shrinking of the extremities, (in which, if inflammation had then existed, it would have disappeared,) loss of sensibility, coma, confusion of mind, delirium, spasms, hemorrhage from the nose, mouth, and ears, mortification of the extremities, universal coldness and torpor:—that most of those who survived the march were attacked with rheumatism, inflammation of the lungs, pleura, or throat, low fevers, deafness, impaired vision, neuralgia, paralysis, diarrhæa, &c.

In regard to the treatment of inflammation, the general indication is to remove the proximate cause, by increasing the circulation through the capillaries of the affected part, and thus promote resolution, before effusion, suppuration, ulceration, or mortification come on.

In accordance with the fact which has been

fully established in the foregoing parts of this work, that caloric is the cause of vital force by which blood is conveyed through every part of the body, it has been found to be by far the most important of all remedies in diminishing and preventing inflammation. Dr. John Thomson declares, that "in all inflammations of the abdominal viscera, there are no means of cure, (blood letting excepted,) which afford such sudden and permanent relief as may be obtained from hot fomentations and warm bathing:—that in cases of suppuration, they shorten the process, and in all cases of severe pain afford singular relief:—that it *seems doubtful whether fomentations and poultices have any power independently of their temperature*." And he very properly recommends that the latter should not only be removed every few hours, but covered with several folds of flannel for retaining the warmth. Yet he adds, that the manner in which they act is unknown. (Lectures on Inflammation, pp. 173. 188. 332.)

We are also informed by Dr. Macartney, in a recent work on the same subject, that in sprains, lacerations, punctures, gun-shot wounds, contusions, fractures near joints, and all violent injuries attended with a shock to the nervous system, there is nothing so soothing and stimulating to the patient as the influence of steam, (at a high but comfortable temperature,) which removes all pain and consciousness of injury in a very short time;

and, as might naturally be supposed, that it prevents traumatic tetanus. He adds, that the warm bath increases the action of the skin, and all the other secretions, by *sympathy*. (pp. 178. 193.)

But Thomson and Macartney are not the only practitioners who have given their testimony in favour of external warmth in the treatment of inflammation. In the Archives Générales de Medicine for October, 1835, there is an article on the influence of heated air on wounds and ulcers, by M. Jules Guyot, the substance of which he has reduced to the following propositions:—

1. "That wounds have always healed more rapidly when surrounded by air above 85° without dressing, than with or without dressing at lower temperatures:—

2. That some wounds have healed in a heated atmosphere, which have not done so at ordinary temperatures:—

3. That in the former state, the majority of wounds healed *without inflammation or suppuration, but not in the latter*:—

4. That *wounds have ceased to suppurate when exposed to heat, and undergone the same healing process as fresh wounds*:—

5. That *an ulcer will heal without any other local application than an increased temperature*:—

6. That heated air has caused the formation of a large cicatrix, in forty-eight hours, over an

old ulcer; and in all cases is highly favourable to cicatrisation.

7. That instead of giving rise to inflammation, it checks its progress:

8. That heat is useful in scrofula, rheumatism, white swellings, phthisis, amenorrhea, paraplegia and other paralyses."

To those who are opposed to all reasoning on the first principles of medical science, it may be agreeable to learn that the practice of Dr. Macartney and M. Guyot was not adopted from any peculiar theoretical views in regard to the physiological agency of heat, but from clinical observation and experience. That blisters and rubefacients produce their good effects in deep seated inflammations, by increasing the action of the capillary vessels, and thus relieving congestion, might naturally be inferred from the elevation of temperature they produce in the parts to which they are applied, and from their influence in augmenting the vigour of the general circulation. Hence their utility in inflammation of the lungs, pleuræ, throat, brain, stomach, bowels, liver, and other organs, as also in typhus, apoplexy, paralysis, and other cases of languid circulation.

Another indication in the treatment of inflammation is to diminish the action of the heart when too violent, by which more blood is forced into the weakened vessels than can be circulated through them, and the local congestion augmented. This

may be done by moderate blood-letting, which may also be resorted to in cases of extreme plethora, or when there is more blood than the heart has the power of forcing freely through the body. And local plethora may be relieved by the application of leeches, should fomentations fail. But we ought never to bleed in health, because blood is the immediate source of life and power to all the organs; and very rarely in disease, because the process of sanguification is then diminished. Cullen rightly observes, that in pneumonia it favours effusion into the bronchial cells and prevents expectoration, when carried too far.* Hunter also says, that excessive bleeding often induces dropsy and convulsions; while Dr. M'Culloch assures us, that it causes delirium, paralysis, and madness.

The leading object should always be to restore the action of the weakened vessels, by a judicious and varied application of the agent on which all the powers of life depend. Perhaps there is no better method of treating old ulcers than by fre-

* In regard to the beneficial influence of mercury in removing the effusion of lymph in cases of croup, pneumonia, bronchitis, pleurisy, peritonitis, pericarditis, hepatitis, and iritis, Dr. Alison truly observes, that there has been much exaggeration:—that when given so as to produce salivation, it is oftener followed by an aggravation than by any improvement of the symptoms:—that it frequently causes a dysenteric affection of the bowels, and produces or augments scrofula, when there is a tendency to that disease. (Cyclopedia of Medicine, Part xxiv. p. 96.)

quent fomentations, the application of simple cerate, and wrapping the affected limb with a flannel roller, which is not only more warm but more elastic than a cotton bandage.

And now that I have brought this laborious undertaking to a close, it remains for competent judges to decide how far the principles developed have been founded on a legitimate and comprehensive induction from facts. If true, they must be realized in all the practical concerns of human life, but more especially in improved methods of preserving health and curing diseases. Animated by the grandeur of the subject, and a deep conviction of its vast importance to the welfare of mankind, I have committed myself with unreserved confidence to the guidance of nature, undismayed by the magnitude of the enterprise; believing with Bacon, that in science, as "in the affairs of civil government, it is better to change many things than one;" and with Sir Edward Bulwer, that "there does not exist one prejudice which can be called salutary, nor one error beneficial to perpetuate." (*The Disowned*, ch. xxii.)

During the prosecution of this task, I have been often reminded of the many deeply rooted prejudices by which the reformer is surrounded: that the mass of mankind have in all past ages been ungrateful to their best friends; that it is generally a thankless office to oppose opinions

long sanctioned by custom, and the authority of distinguished names. To all such admonitions I would reply in the words of Sydenham, that "it is better to assist mankind than to be commended by them:"—that if the multitude have been always fond of mysteries, fables, traditions, and quack doctors, it is because their leaders have permitted the great science of nature to remain a sealed book—the profoundest of all mysteries. But when the veil which has so long concealed the beautiful mechanism of the universe shall have been drawn aside, all subordinate mysteries will vanish, and with them a countless multitude of pernicious errors, which have hitherto obstructed every avenue to the temple of wisdom. Nor can there be a rational doubt, that a complete knowledge of the prime Mover would be the perfection of science, and enable us to predict whatever should come to pass in the regular course of nature.

It must not, however, be supposed, that more than a general outline of this immense subject has been attempted in the foregoing work. Nor does the Author presume to flatter himself that he has been always free from error. Nor should it be expected, that the pioneer of unexplored regions, can become so fully acquainted with all their various productions as those who follow, and have more leisure for research into details.

When the extreme difficulty of the inquiry is duly considered, and the results obtained are contrasted with the previous state of our knowledge, it is hoped that men of enlarged views will be more studious to correct than to censure.

CORRIGENDA.

The Reader is requested to observe, that, as the Preliminary Chapter, and the latter part of Chapter III. Book I. were cancelled after the Work was printed, some few of the subsequent references to them will be found not to correspond with the present paging.

Page	Line	
8,	4,	(*note*) *for* Berkley *read* Berkeley.
27,	10,	*after* or *insert* that.
46,	25,	*for* bond *read* band.
94,	11,	(*note*) *for* as it in *read* as it is.
113,	27,	*for* its particles *read* particles of chlorine.
119,	3,	*after* and *insert* those of.
129,	2,	*for* its protoxide *read* protoxide of silver.
145,	16,	(*Table*) *for* 21·62, *read* 34·32.
159,	8,	*for* page 26 *read* page 4.
161,	23,	*for* page 24 *read* page 3.
163,	4,	(*note*) *for* page 26 *read* page 6.
164,	2,	*for* or *read* nor.
167,	5,	omit the comma after the word Guyton.
168,	17,	*for* page 28 *read* page 38.
175,	7,	*for* freeze *read* frost.
177,	17,	omit reference to page 106.
224,	19,	*after* Chapter iii. *insert* Book i.
232,	2,	*for* 70^0 *read* 90^0.
269,	16,	*for* cubit *read* cubic.
271,	12,	*for* solar attraction *read* planetary motion.
279,	23,	*for* second causes *read* physical causes.
284,	3,	*for* modified effects, *read* modifications.
290,	4,	*for* attraction *read* nature.
397,	1,	*for* Pouillet Scrope *read* Poullet Scrope.
398,	6,	*for* his father *read* the elder Pliny.
407,	2,	*for* five to six *read* four to five.
426,	1,	(*note*) *for* Æspinus *read* Æpinus.
430,	11,	*for* acception *read* acceptation.
432,	29,	*for* second causes *read* physical causes.
445,	16,	*for* numerous *read* many.
448,	15.	*for* expected *read* supposed.

CORRIGENDA.

Page	Line
487,	10, *for* foundations *read* elements.
490,	14, *for* later *read* early.
502,	et seq. *for* Tiedmann *read* Tiedemann.
504,	20, *for* Pritchard *read* Prichard.
506,	24, *after* facts *insert* a semicolon.
534,	1, *for* west *read* east.
553,	23, and 561, *for* Mayo *read* Mayow.
555,	12, *for* parting with *read* mixture with.
558,	21, *after* water *insert* at 47·5°.
574,	12, *for* consists *read* consist.
574,	6, (*note*) *for* 8 per cent. *read* 18; *and for* 8 lbs. *read* 9 lbs.
645,	27, *for* Locke *read* Boyle; *and for* Bordeau *read* Bordeu.
656,	10, *for* takes place *read* coagulates.
657,	11, *after* than *read* the blood.
664,	13, (*note*) *for* Stephens *read* Stevens.
666,	9, *for* their *read* the.
667,	5, *for* infusions *read* substances.
571,	9, *for* muscular system *read* muscles.
672,	21, *for* less *read* more.
673,	27, *for* vegetation *read* vegetables.
680,	14, *after* decomposition *insert* and coagulation of the blood are.
713,	4, (*note*) *after the word* vegetable *omit* to animal.
735,	18, *for* Van Kenedy *read* Vans Kenedy.
738,	4, (*note*) *for* *ανιμος read ανεμος*.
740,	7, *for* celestial fluid *read* the celestial fluid.
797,	7, (*note*) *for* bring on *read* prevent.
820,	1, *after* demonstrate *insert* that.
833,	3, *for* Saizy *read* Saissy.
847,	25, *for* where *read* at which.
859,	11, (*note*) *for* Clark *read* Clarke.
895,	26, *for* contains *read* contain.
901,	27, *for* are *read* is.
902,	9, (*note*) *after* system *insert* and.
919,	2, (*note*) *for* purely farinaceous matter *read* constituents.
920,	4, (*note*) *for* does *read* do.
926,	3, from bottom, *for* is *read* are.
941,	9, *after* than *read* they have had.
949,	12, *after* vessels *insert* are.
957,	10, *after* any *omit* other.
960,	9, (*note*) *for* that organ *insert* the brain.
963,	3, (*note*) *for* interferes *read* interfere.
974,	29, *for* Lænnec *read* Laennec.
975,	27, *for* cessation *read* diminution.
980,	20, *for* destroy *read* prevent.
983,	9, *for* murder *read* murderer.
988,	6, *for* found *read* formed.
1000,	12, *for* Richlieu *read* Richelieu.
1003,	30, *after* characters *insert* of.
1025,	12, *for* in *read* of.